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ENERGY IN ONTARIO
THE OUTLOOK AND POLICY IMPLICATIONS

; report.

VOLUME TWO

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VOLUME TWO

ENERGY IN ONTARIO

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Uranium

The conversion, or "burning", or uranium fuel by fission in a reactor to release thermal energy may be expressed either by the percentage of fissionable atoms which have undergone fission or by the thermal energy released from unit weight of fuel in which fission takes place. The fuel "burn-up" for Pickering nuclear station, for example, is 8,000 megawatt-days thermal energy per metric ton of natural uranium fuel or 297 million Btu per pound of natural uranium. The design burn-up for the Bruce nuclear station is 9,600 megawatt-days per metric ton of natural uranium. Because of the wide variation in fuel "burn-up" amongst the various nuclear reactors there is no standard "heat rate" for nuclear reactor generating stations as there is for stations in which fossil fuels are burned.

Advisory Committee on Energy

MOWAT BLOCK
QUEEN'S PARK
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TO HIS HONOUR

THE LIEUTENANT GOVERNOR OF THE PROVINCE OF ONTARIO

MAY IT PLEASE YOUR HONOUR:

We, the members of the Advisory Committee on Energy, were appointed by Order in Council dated August 18, 1971, to undertake a comprehensive review to ascertain the future energy requirements and supplies for Ontario, and to make such recommendations concerning policies as are, in the Committee's opinion, necessary to ensure that these requirements will be met. The results of the Committee's deliberations are contained in two volumes as set out in the Table of Contents.

We hereby submit to Your Honour Volume Two of our report entitled Energy In Ontario.

John J. Deutsch

John J. Deutsch
Chairman

March 5, 1973

Ontario

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ONTARIO

EXECUTIVE COUNCIL OFFICE

OC-2483/71

Copy of an Order-in-Council approved by His Honour the Lieutenant Governor, dated the 18th day of August, A.D. 1971.

The Committee of Council have had under consideration the report of the Honourable the Treasurer of Ontario and Minister of Economics, dated the 10th day ofAugust, 1971, wherein he states that, –

WHEREAS the Government of Ontario has expressed its determination to assure the adequacy of energy supplies for this Province, and

WHEREAS the first step in this process was the establishment of Task Force Hydro to review the function, structure, operation, financing and objectives of the Hydro Electric Power Commission of Ontario,

The Honourable the Treasurer of Ontario and Minister of Economics therefore recommends that a special committee be appointed, to be called the Advisory Committee on Energy, to undertake a comprehensive review to ascertain the future energy requirements and supplies for Ontario, and to make such recommendations concerning policies and ways and means of supply as are in its opinion necessary to ensure that these requirements will be met.

The Honourable the Treasurer of Ontario and Minister of Economics further recommends that all relevant matters be studied and taken into account by the Committee, including the following considerations:

(a) The social and economic benefits to be obtained from a balanced and integrated energy policy.

(b) The relationships of energy requirements and policies to Provincial resources policies and programs.

(c) The relationships with provincial environmental policies and programs.

(d) The co-ordinative action required for the development, manufacture, distribution and marketing of energy for Ontario's needs.

(e) The implication of national and international energy policies and sources of supply on Ontario's energy requirements.

(f) The means by which co-ordination can best be achieved between energy policy and regional and community development and provincial land use management.

(g) The sources of funding, capital investments and other financial implications.

(h) The organizational structures to implement the recommendations on an on-going basis and to provide for continuing analysis and review of energy policies and programs.

And the Honourable the Treasurer of Ontario and Minister of Economics further recommends that the members shall be Doctor John James Deutsch, who shall be chairman, and such other members as shall be recommended by the Treasurer of Ontario and Minister of Economics and approved by the Lieutenant Governor in Council.

The Committee of Council concur in the recommendations of the Honourable the Treasurer of Ontario and Minister of Economics and advise that the same be acted on.

Certified,
J. J. Young,
Clerk, Executive Council

PREFACE

This volume, in thirteen chapters, is the main report of the Advisory Committee on Energy. Volume One summarized this report and included the principal recommendations of the Committee. Statistics quickly become out of date, particularly so with the rapid changes taking place in the energy field, but these should not alter the major conclusions reached by the Committee.

In preparing its report, the Committee made maximum use of existing studies published by others and supplemented these where necessary with additional studies which were specially commissioned. The Committee met monthly over a period of more than a year. It reviewed and discussed all submissions and draft chapters of the report.

Special mention must be made of the valuable assistance provided by the staff of various government ministries (see Appendix C). Several people contributed to the work of the Committee by preparing reports in their field of competence. An Energy and the Environment Subcommittee, under the chairmanship of Dr. K. E. Tempelmeyer, provided valuable support and assistance to the Committee as well as to Task Force Hydro. The report of this Subcommittee is a landmark in its field. These people and others gave a depth to the work of the Committee which would not otherwise have been possible except over a much longer period of time – and at substantially greater cost.

The Committee has maintained a close working relationship with the various study groups of Task Force Hydro. For example, the review of nuclear power was carried out as a joint study project and the report will be published in the Task Force Hydro series.

The Committee is grateful to the many companies, organizations, governments and individuals who, through submissions, letters and interviews have contributed greatly to the understanding of the issues. The Government of Canada, through the Department of Energy, Mines and Resources and the National Energy Board, has been most helpful. Mr. Norman Chappell, Energy Counsellor, the Canadian Embassy, Washington, D.C., and Mr. J. L. Orr, then the Science Counsellor, the Canadian High Commission Office, United Kingdom, also provided invaluable assistance and cooperation.

We wish to express our appreciation to all of these and to the small dedicated staff who assisted the Committee.

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Chapter 1

Energy in the Ontario Economy

BASIC ECONOMIC FACTORS

1:1 At the outset, it is desirable to present the background of basic economic factors which are likely to have a strong influence on the demand for and the role of energy in the Ontario economy over the next several decades.

1:2 The projections that follow are not specific forecasts which try to take into account the effects of unforeseen circumstances and future changes in policy, rather, these projections have been developed from the past performances of the Ontario economy and as far as possible, take into account only current and foreseeable future trends.

1:3 Estimates prepared for the Advisory Committee on Energy point to a population in the neighbourhood of 11 million people in Ontario by the year 1990. The increase in population will likely result in a million new households and probably a doubling in the number of passenger automobiles. Employment for a growing population implies a certain rate of economic growth and therefore of industrial expansion. These increases in economic activity in turn imply certain increases in levels of demand for energy. The resulting projections can serve as useful and indeed essential reference points for analysis and as indicators of emerging problems which will need timely attention.

1:4 In comparing the next two decades with the past two decades, perhaps the most important single factor to be noted is a slowing down in population growth. The average annual growth rate of population in Ontario between 1950 and 1970 was 2.7 per cent. This reflected not only a surge in family formations in the 1950s, but also very substantial immigration. Both of these factors are liable to slow down significantly in the next two decades. Birth rates have been declining steadily for some years. While this decline may level off, the rate of population increase over the next twenty years is liable to be significantly lower. We have assumed an average annual growth of 2.0 per cent for Ontario over the next several decades. On this basis, Ontario population would rise from 7,637,000 in 1970, to slightly more than 11 million by 1990.

1:5 An important aspect of population growth is the number of household formations each year. In the past two decades the average growth rate was 3.1 per cent resulting from the high rate of family formation and the "undoubling" effect as the backlog of demand for housing was eased. In the next twenty years, the rate of household formation is expected to slow down to 2.2 per cent and the number of persons per household to decline. For example, in 1950 there were 3.79 persons per household on the average in the province, and by 1970 this had been reduced to 3.65 persons. By 1990 the ratio is expected to be 3.40 persons.

Table 1:1

Ontario Population and Households 1950 - 1990

	Population (000s)	*Households* (000s)	*Persons per Household*
1950	4,471	1,181	3.79
1960	6,111	1,641	3.72
1970	7,637	2,098	3.65
1975	8,400	2,346	3.58
1980	9,200	2,614	3.52
1985	10,250	2,895	3.45
1990	11,200	3,294	3.40
Average Annual Growth Rate			
1950 - 1970	2.7%	3.1%	—
1970 - 1980	2.0%	2.2%	—
1980 - 1990	2.0%	2.2%	—

1:6 Energy consumption is affected also by changing trends in types of housing. In 1970 an estimated one family in five lived in apartments and by 1990 this ratio is expected to reach one in three. The significance of this larger ratio spills over into such areas as urban transportation requirements, land-use

planning, space heating requirements, etc. The average rate of growth of apartment housing units in Ontario is expected to be 4.3 per cent per annum over the next twenty years, compared to 1.5 per cent for other types of accommodation. These, combined, give the total household growth rate of 2.2 per cent. Between 1970 and 1990 approximately 1.2 million new households will be established in the province.

Table 1:2

Ontario Gross Domestic Product 1950 - 1990

(In 1961 Constant Dollars)

	Billions of Dollars	*Dollars per Capita*
1950	9.0	2,004
1960	13.8	2,260
1970	22.6	2,963
1975	31.2	3,429
1980	39.3	4,000
1985	48.5	4,575
1990	58.0	5,352
Average Annual Growth Rate		
1950 - 1970	4.7%	2.0%
1970 - 1990	4.9%	3.0%

1:7 Assuming no major depression, gross domestic product in Ontario is expected to continue to increase relatively rapidly over the next two decades. In real terms, that is in 1961 constant dollars, the growth rate over the past twenty years has averaged 4.7 per cent per annum, and a slight increase to 4.9 per cent per annum is expected over the next twenty years. As a result of the slowing down in the rate of population increase and the modest acceleration in real growth, gross domestic product per capita (in constant dollars) is expected to increase by 3.0 per cent per annum over the forecast period, compared to an average of 2.0 per cent per annum between 1950 and 1970.

1:8 One final economic indicator which is of great significance, not only from the viewpoint of energy consumption but also from the viewpoint of environmental protection, is the registration of private automobiles. These increased by an average of 5.5 per cent per annum between 1950 and 1970. This very high rate of increase reflects the 1940s backlog of demand for automobiles which was largely fulfilled during the 1950s. The outlook for the next years is for a smaller average annual growth rate of 3.3 per cent reflecting a more normal pattern as well as the increasing emphasis on other modes of transportation.

Table 1:3

Ontario Passenger Automobile Registration 1950 - 1990

	Registrations per Auto	*Persons (000s)*	*Autos per Household*
1950	887	5.04	0.75
1960	1,733	3.53	1.06
1970	2,576	2.96	1.23
1975	3,144	2.67	1.34
1980	3,624	2.54	1.39
1985	4,165	2.46	1.44
1990	4,965	2.26	1.50

1:9 The density of motor vehicles in Ontario has increased remarkably in the last two decades. In 1950, for example, there were 5.04 persons per auto and this dropped sharply to 2.96 by 1970. The density is expected to continue to increase but at a sharply reduced rate, reaching 2.26 persons per auto by 1990. The ratio of automobile registrations to households, was 0.75 in 1950. Ten years later the ratio was 1.06 and in 1970 1.23. By 1990 it is anticipated that there will be 1.50 automobiles per household in Ontario. This reflects the growing trend to two-car families. It is estimated that currently there are half a million "second cars" in Ontario and this number is expected to more than double by 1990.

1:10 Some two and a half million automobiles in an area the size of Ontario need not present a major environmental problem. But the concentration of vehicles in particular areas such as the Toronto/Hamilton area is a matter of concern. At present approximately 900,000 passenger cars[1] are registered in the Toronto/Hamilton area, or 35 per cent of the provincial total. If, for example, we apply a growth rate of 4 per cent to the 1970 registrations, the Toronto/Hamilton area would have a concentration of some two million passenger automobiles by 1990.

GROWTH AND ENERGY CONSUMPTION

1:11 The relationship between economic growth and energy consumption has been widely documented.[2] Also there has been a close relationship between the use of energy and productivity and material standards of living. Regions such as Africa, Latin America, the Far East and the Middle East have annual per capita energy consumption of less than 50 million Btu and per capita incomes below $500. At the top end of the scale, regions such as the United States, Canada, and Ontario have annual per capita energy consumption in excess of 275 million Btu and per capita incomes in excess of $3,000. The same relationships exist in any one region over time. In Ontario, for example, energy use increased from 228 million Btu per capita in 1950 to 308 million Btu in 1970. Over the same period gross domestic product per capita rose from $2,004 to $2,963.

---

[1]Commercial vehicles would add another 110,000.

[2]e.g., (a) U.S. Department of the Interior, *United States Energy - A Summary Review,* January 1972; (b) L. G. Brooks, *Energy & Economic Growth, Atvin;* (c) Imperial Oil Limited, *Submission to Advisory Committee on Energy,* January, 1972.

Table 1:4

Comparison of Gross Domestic Product and Energy Consumption 1950 and 1970

	1950	*1970*	*Annual Growth Rate* (Per cent)
Gross Domestic Product	($ 1961 - Billions)		
Canada	21.8	54.6	4.7
Ontario	9.0	22.6	4.7
Energy Consumption and Gross Domestic Product (Thousands Btu consumed per dollar of GDP)			
Canada	117	117	
Ontario	113	103	
Energy Consumption	(Trillions Btu)		
Canada	2,600	6,400	4.6
Ontario	1,020	2,350	4.3
Energy Consumption per Capita	(Millions Btu)		
Canada	187	298	2.4
Ontario	228	308	1.5

ENERGY MEASUREMENT

In North America the most widely used measurement unit in the study of energy has been the British thermal unit (Btu). It is a small unit (the amount of heat required to raise the temperature of a pound of water one Fahrenheit degree) and so will usually be expressed in thousands (10^3), millions (10^6), billions (10^9) and trillions (10^{12}).

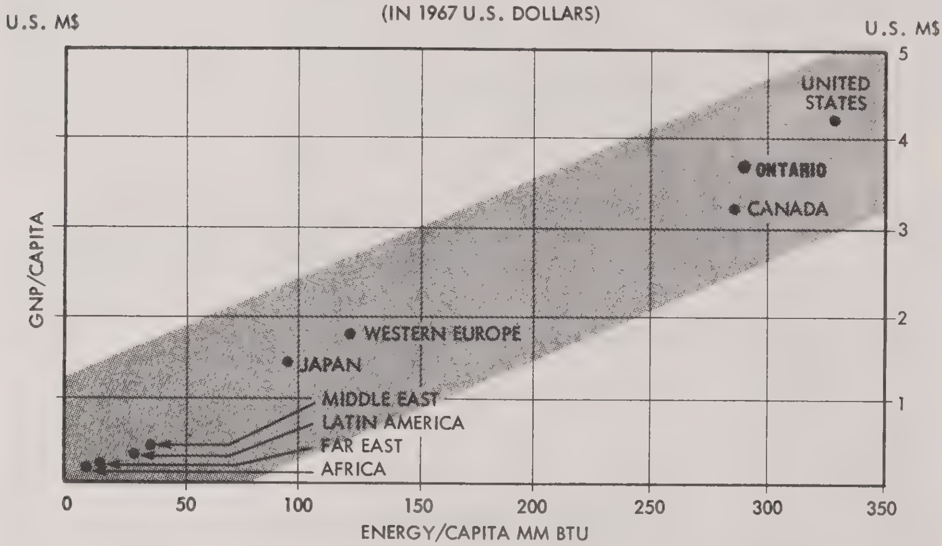
The Btu equivalents of common fuels are as follows:

Fuel	**Common Measure**	**Btu**
Crude Oil	Barrel (bbl)	5,800,000
Natural Gas	Cubic foot (cf)	1,000
	Thousand cubic feet (mcf)	
Coal	Ton	24 to 28,000,000
Electricity	Kilowatt hour (kWh)	3,412

Thermal electric power generation ranges in efficiency from about 30 per cent for a nuclear station to 40 per cent for a modern coal-fired generating station. Thus, for a kilowatt hour of output (3,412 Btu) the energy input will range from 11,000 Btu to 8,500 Btu. The extra Btu are lost as waste heat. The common measure used for the electric generating capacity of large utility stations is the megawatt (MW) which is one thousand kilowatts.

Figure 1:1

The Relationship in 1969 Between Per Capita Gross National Product and Per Capita Use of Energy in Various Countries and Regions

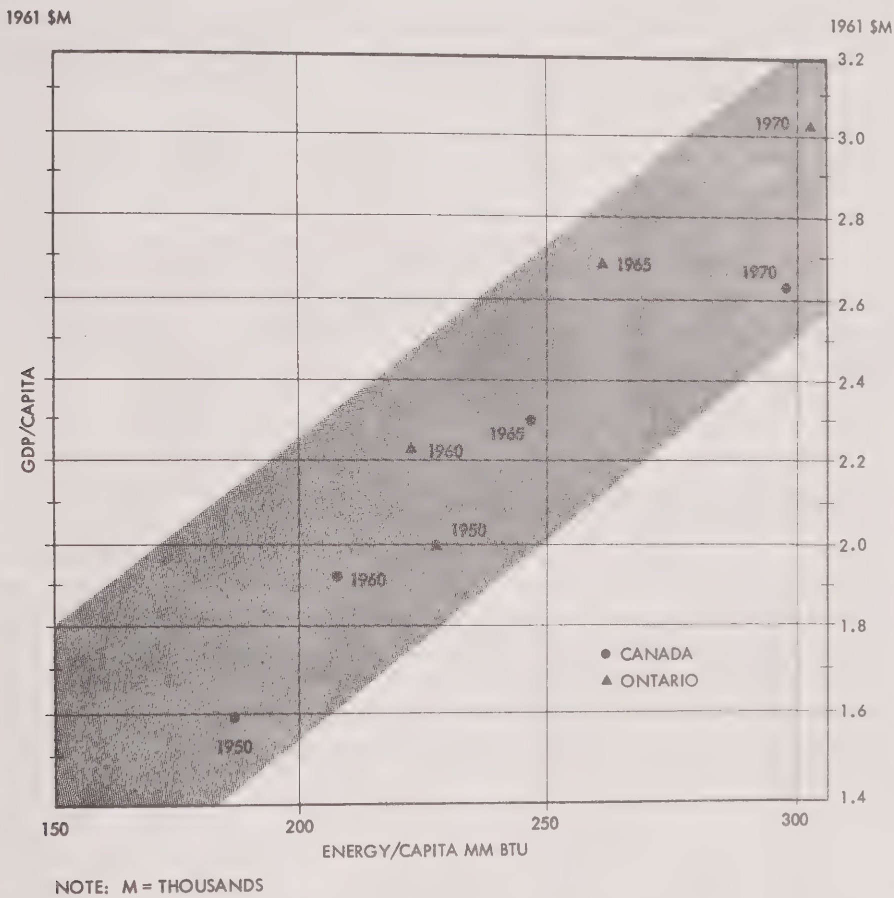


NOTE: M = THOUSANDS

Source: Imperial Oil Limited *Submission to the Advisory Committee on Energy*

Figure 1:2

The Relationship Between Per Capita Gross Domestic Product and Per Capita Use of Energy in Canada and Ontario for Selected Years



Source: Imperial Oil Limited *Submission to the Advisory Committee on Energy*

1:12 Energy use, economic growth and improved standards of living usually increase together, although not precisely in step. For example, during periods of transition from one energy source to another, or when a major technological breakthrough is introduced, it is possible to have increased capital intensity, enhanced productivity and improved living standards and reduced energy consumption levels. During the 1950s in Canada, coal was phased out as the principal energy source, declining from 45 per cent of total input in 1950 to 15 per cent in 1960. Over the same period energy use declined from 117 million Btu per 1971 dollar of gross domestic product to 109 million Btu. In Ontario, energy use per unit of gross domestic product declined by 10 per cent in the 1950s and has remained stable during the past decade. During the period 1950-1970, real output gained by 4.7 per cent per annum and energy consumption by 4.3 per cent per annum.

1:13 The importance of energy in economic productivity and in standards of living is illustrated by the fact that the production of energy constitutes approximately eight per cent of Canada's gross domestic product and is equivalent to about $275 per capita in 1970.

ENERGY AND INDUSTRY

1:14 In manufacturing the cost of energy varies widely. In 1970 costs of fuel and electricity for all Ontario manufacturing accounted for four per cent of value added - $417.8 million out of $10,524.7 million. The ratio ranged from one per cent in the clothing and knitting industries to ten per cent in the non-metallic minerals group. The largest energy user in 1970 was the primary metal products group whose outlays for energy totalled $90 million. In this sector the expenditures on fuel and electricity represent about eight per cent of value added.

Table 1:5

Fuel and Electricity Cost - 1970

	As a Percentage of Manufacturing Shipments	*As a Percentage of Value Added in Manufacturing*
Canada	1.9	4.5
Ontario	1.7	4.0
Quebec	2.0	4.6
Prairies	1.8	4.9
British Columbia	2.4	5.7
Atlantic	3.3	8.4

Table 1:6

Cost of Fuel and Electricity as a Percentage of Value added in Five Dominant Energy Consuming Industries

	1970
Food & Beverages	3.2
Paper & Allied Products	9.9
Primary Metals	8.2
Non-metallic Minerals	10.7
Chemicals & Chemical Products	7.5

1:15 Estimates prepared for the Advisory Committee on Energy point to a tendency for the proportion of energy cost to value added to continue to decrease, with the exception of primary metals, as projected from historical trends. The five dominant industries (food and beverages, paper and allied products, primary metals, non-metallic minerals and chemicals and chemical products) account for over 70 per cent of total energy consumption in manufacturing in Ontario. A recent study[3] concluded that even for those industries for which energy is a major operational cost, it is seldom the determining factor in decisions to locate or expand. Nevertheless, all elements of cost, including energy costs, can be determining factors in the survival of marginal operations such as the pulp and paper industry where extremely strong competition is experienced in the export market.

Table 1:7

Ontario Manufacturing Energy Cost by Fuel, 1970

Fuel	*Value $000*	*Percentage*
Anthracite and Sub-bituminous	317	0.1
Canadian Bituminous	5,642	1.4
Imported Bituminous Coal	18,952	4.5
Lignite	889	0.2
Coke	8,623	2.1
Gasoline	26,353	6.3
Fuel Oil	57,842	13.8
Liquefied Petroleum Gas	2,573	0.6
Natural Gas	98,386	23.6
Electricity	186,121	44.5
Other	12,152	2.9
Total	417,850	100.0

[3]Ontario Research Foundation, *Northern Ontario Industrial Energy Study*, Toronto, 1969.

1:16 In Ontario, expenditures on electricity are by far the largest element in the energy costs of manufacturing being more than twice the outlay on either natural gas or fuel oil. Natural gas has become the major industrial fuel source and may be expected to capture a large portion of future demand as a preferred substitute for fuel oil and coal. Although electricity is the most expensive energy source it will continue to experience better than moderate growth because of its versatility. All energy sources are readily available to industry in southern Ontario. The availability of natural gas in northern Ontario, with a few exceptions, is restricted to the vicinity of the TransCanada PipeLines gas transmission system.

Chapter 2

A Supply/Demand Pattern for Energy

INTRODUCTION

2:1 The historic relationships noted in Chapter 1 between population, the gross domestic product and energy demand provide a starting point for projections of our future energy requirements in Ontario. The trend in per capita energy consumption and the amount of energy required for each unit of gross domestic product (a constant dollar) can serve as a rough check on the basic figures. In Table 2:1 the projected energy requirement in 1980 is more than 50 per cent above 1970 and by 1990 is projected to be two and one half times our 1970 energy consumption. When related to population, this projection implies an increase in the use of energy by each person in Ontario of one-third by 1980 and of two-thirds by 1990.

2:2 However, when related to the projected growth of the economy, the amount of energy required for each unit of GDP shows no increase over the forecast period and in fact the ratio has remained remarkably steady since the 1950s. This past relationship suggests that energy consumption will continue to increase at about the same rate as the rate of growth of the economy, assuming no major efficiency improvements in the economy comparable to the introduction of the diesel engine which occurred during the 1950s.

Table 2:1

Growth and Energy Consumption in Ontario 1950-1990

Year	*Population* (Millions)	*Gross Domestic Product* ($1961 - Billions)	*Total Energy Use* (Trillions Btu)
1950	4.4	9.0	1,020
1960	6.1	13.8	1,412
1970	7.6	22.6	2,350
1980	9.2	39.3	3,700
1990	11.2	58.0	5,700

	Energy Use per Capita (Millions Btu)	*Energy Use and GDP* (Thousands Btu/$1961)
1950	228	113
1960	229	102
1970	308	103
1980	402	94
1990	508	98

2:3 On the other hand, if the energy requirement is projected at a lower figure than that shown in Table 2:1 – such as energy consumption per person remaining at today's level – total energy consumption in 1990 would be about 50 per cent above 1970 energy consumption. Energy per unit of gross domestic product would decline by 50 per cent which seems unlikely since at the same time per capita incomes will have risen to over $5,000. The projections, therefore, for total energy use in Table 2:2 are not inconsistent with the population and gross domestic product projections which we have adopted.

Table 2:2

Ontario Energy Demand by End Use, 1950-1990

(Trillion Btu)

	Residential & Commercial	*Industrial*	*Transportation*	*Conversion Loss and Own Use*	*Total*
1950	300	330	230	160	1,020
1960	380	440	250	342	1,412
1970	625	700	394	631	2,350
1980	890	1,190	640	980	3,700
1990	1,200	1,950	1,100	1,450	5,700
		(Percentage of total)			
1950	29.4	32.4	22.5	15.7	100.0
1960	26.9	31.2	17.7	24.2	100.0
1970	26.6	29.8	16.8	26.8	100.0
1980	24.0	32.2	17.3	26.5	100.0
1990	21.1	34.2	19.3	25.4	100.0

THE ENERGY PATTERN IN ONTARIO

By Demand Sector

2:4 Between 1950 and 1970, total Ontario energy requirements increased at an average annual rate of 4.2 per cent. Conversion, loss and own use, increased at an average annual rate of 7.7 per cent over the 20-year period. The principal component of this latter group is the thermal loss in electric power generation. It also includes a wide range of energy applications such as refinery fuel, pipeline fuel and losses by both.

2:5 The technical factors behind these varying energy requirements of the past two decades include a major shift from coal to oil in the 1950s and to gas in the 1960s. These shifts reduced the input requirement of raw energy because of the improved efficiency achieved with the superior fuels.[1] The dieselization of the railroads, the jet engine, oil space heat all tended to reduce energy inputs, but despite these improvements in efficiency, the total energy demand was rising sharply.

2:6 The outlook for the rest of this decade suggests an overall increase in Ontario energy demand of 4.6 per cent per year. By 1980 total requirements will be 3,700 trillion British thermal units close to 60 per cent more than for 1970. By 1990 total requirements are projected to be 5,700 trillion British thermal units or nearly two and one-half times the demand for 1970. The above average increases in the industrial and transportation demand for energy reflect the fact that the advantages of improved conversion, which held down the rate of increase in the last two decades, have been utilized and in future the energy requirements for these sectors will reflect more accurately the real growth in demand.

2:7 A major new influence in the next decade, and beyond, will be the environmental improvement controls which will tend to increase energy consumption. Conversion to lead-free gasoline may require an additional 70 thousand barrels per day in Ontario by 1980. Offsetting this, however, will be a trend towards smaller cars. By the 1980s, new technology such as the Wankel engine and electric cars may become more significant. However, the electric car merely changes the demand from gasoline to other fuels required to generate electricity.

2:8 Much of the transition from the "pre-environmental" to the "post-environmental" era will be accomplished by 1980. Thereafter, energy growth rates in the industrial and the transportation sectors might be expected to slow down. However, greatly increased leisure time will maintain strong pressure on demand for transportation in all forms partially offsetting economies of mass transit and smaller cars. Residential and commercial energy demand will also slow down because the rate of population growth will be declining. Offsetting this, however, will be the increasing role of electric energy in the total energy supply.

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[1]Some examples of the approximate ratio of net useful energy output to gross fuel energy input are: 5 per cent for steam locomotives, 25 per cent for diesel locomotives, 25 per cent for automobiles, 75 per cent for gas space heating, 95 per cent for electric water and space heating at the point of application.

2:9 In 1970, approximately 27 per cent of total energy consumption in Ontario was accounted for by the residential and commercial sector. Of this total, about three-quarters was required for space heating. The remainder was consumed mainly in electrical and gas appliances. Energy demand for air conditioning was negligible (of the order of one per cent).

2:10 Oil consumption has grown steadily and gas consumption has grown very rapidly for space heating. Electrical resistance heating is presently of the order of one per cent of total fuel use in this sector and coal consumption is small and declining rapidly.

2:11 The transportation sector accounted for about 17 per cent of total energy consumption in Ontario in 1970. Fuel consumption by motor vehicles in turn accounts for about four-fifths of energy consumed in transportation. It is expected that transportation will continue to account for roughly the same percentage over the forecast period.

2:12 It is unlikely that the internal combustion engine will be replaced on a broad scale in the near future. Possible alternatives to the internal combustion engine now in the experimental stage require a great deal of further development. Assessment of changes in energy consumption through technological development must therefore first take account of newly instituted anti-pollution regulations for the internal combustion machine.

2:13 Other propulsion systems currently under development (although not displacing the internal combustion engine within the critical periods during which rigid environmental protection standards will be introduced) may well come into widespread use. These include gas turbines, external combustion engines, electric cars, improved urban transportation systems and improved long-distance freight and passenger movement systems.

2:14 Development of the storage capacity of batteries has not reached a point which would give the electric car long-range operational capability. Although attempts are being made to develop a battery which would permit a range of at least two hundred miles, it is generally accepted that it will be a number of years before technology will have provided an all-electric substitute for the North American family car at a competitive price. The most logical first application of the electric car would be for the second or downtown car, leaving highway travel for the conventional automobile.

2:15 Energy input to the industrial sector (primarily the manufacturing sector) presents a very complex picture because of the diversity of applications. Industrial energy requirements include: a) electrical energy for lighting and motive power; b) space heating; and c) energy for a wide variety of specific industrial applications such as process steam production and metallurgical furnaces. Energy demand by industry acounts for one-third of total energy consumption in Ontario, and has grown steadily. However, the demand for specific types of energy is changing rapidly. The use of gas has grown at a fast pace, oil is maintaining its market share and coal is declining significantly. The relative use of electricity is increasing moderately.

2:16 Industry is expected to continue to account for about one-third of total energy consumption in Ontario throughout the present decade. No major technological changes affecting energy use by industry are anticipated even though such changes may be made relatively quickly in certain types of light industry such as the food industry. Particularly in the primary metals and the pulp and paper industries, major innovations not now implemented are unlikely to affect substantially the demand for energy in the next ten years. For example, fifteen to twenty years may be necessary for new processes to be commercially applied throughout the steel industry.

By Supply Sources

2:17 Ontario has a wide range of energy supply sources, but about 80 per cent of the supply originates outside the province. In 1950, 22 per cent of Ontario's energy was supplied by oil, and by 1970 this had increased to 40 per cent. A small quantity of natural gas from local fields has always been produced. When a gas supply from western Canada became available, natural gas sales expanded very rapidly and accounted for close to 20 per cent of all energy in the province in 1970. Coal has dropped sharply in significance, falling from more than half of all Ontario energy in 1950 to about 20 per cent in 1970. Water power increased during the 1950s to 25 per cent of the total energy supply but has been declining in relative importance in recent years reaching 18 per cent by 1970. Nuclear power by 1970 accounted for less than one per cent of the Ontario energy supply.

2:18 In 1950, Ontario's energy demands were relatively simple – 43 million barrels of oil, 23 million tons of coal and 18 billion kilowatt hours of hydro power. There was only a nominal use of natural gas and no nuclear power. By 1970 the picture had changed substantially and the stage was set for a new era which will lean more and more on nuclear energy.

2:19 Looking at the next 20 years, the most significant development will be the sharply increasing role of nuclear energy. Natural gas will increase its share somewhat over the next few years, and should provide about 25 per cent of our energy supply over the next several decades. The contribution of coal will continue to decline sharply. A similar trend in water power will be noted as the available sites in the province have nearly all been developed. The role of nuclear power will increase to about 10 per cent of the energy supply by the end of this decade and to about 25 per cent of our total energy supply by 1990.

2:20 During the period 1950 to 1970, oil requirements had increased more than threefold to 184 million barrels. Another 236 million will be required annually by 1990 – an increase of 128 per cent over the 1970 level. Natural gas increased fourfold during the 1960s, reaching 440 billion cubic feet by 1970. An increase of 218 per cent is anticipated by 1990 when requirements are expected to be 1,400 billion cubic feet. This increase of approximately one trillion cubic feet, represents total sales of gas in Canada in 1970, and would be equivalent to the minimum annual throughput of a major trunk pipeline.

Table 2:3

Ontario Energy Supply 1950-1990

	Oil (million barrels)	*Natural Gas* (billion cubic feet)	*Coal* (million tons)	*Hydro* (billion kWh)	*Nuclear*[a] (tons U_3O_8)
1950	43	–	23	18	–
1960	115	115	13	36	–
1970	184	440	20	43	63
1980	288	950	16	38	1,030
1990	420	1,400	15	37	2,300

(Percentage of total)

	Oil	*Natural Gas*	*Coal*	*Hydro*	*Nuclear*	*Other*	*Total*
1950	22.1	1.2	56.9	17.6	–	2.2	100.0
1960	42.6	8.1	22.7	25.8	–	0.8	100.0
1970	40.7	18.7	21.3	18.3	0.6	0.4	100.0
1980	41.9	27.0	10.8	10.3	9.8	0.2	100.0
1990	38.0	25.0	6.5	6.5	23.9	0.1	100.0

2:21 The quantity of coal required in the future is uncertain. Projections are affected by a number of conflicting factors: there are abundant reserves but transportation difficulties; ecological problems of production; emission problems of consumption; and rising costs of alternate fuels. Coal will play a key role in this decade, bridging the gap between the pre-nuclear and the nuclear eras. Future demand is expected to be moderate but will depend on the balanced resolution of current and future conflicts.

Electric Power

2:22 On a world basis, Canada stands second (with Ontario slightly below the Canadian average) in the per capita use of electric energy. The leading per capita consumers in 1969 were:

1.	Norway	14,452 kWh
2.	Canada	8,959 "
3.	Ontario	8,669 "
4.	Sweden	7,743 "
5.	United States	7,644 "
6.	New Zealand	4,697 "

[a]Based on high nuclear program, see Table 2:4.

2:23 Electricity consumption by market sector in Ontario during 1971 was:

	Billions of kWh	*Percentage*
Residential (including farm and street lighting)	16.3	22.4
Commercial	10.0	13.7
Industrial (including utility plant use)[3]	34.4	47.2
	60.7	83.3
Losses and unallocated	12.2	16.7
Total	72.9	100.0

2:24 Demand for electric energy in Ontario has been doubling about every decade, corresponding to an average long-term annual growth rate of about 7 per cent. On the basis of present policies and circumstances this rate of increase is expected to continue into the 1980s.

2:25 Traditionally, as in other provinces, Ontario has been dependent on hydro-electric power. As recently as 1960, 99 per cent of electric energy generated by Ontario Hydro was by water power. But the number of hydro sites is limited, and steam generating capability was developed very rapidly to meet the growing load requirements. The following table shows the transition from water power and the increasing dependence on steam generation. The use of fossil fuel is expected to peak by 1980 and nuclear power to become the dominant source of electricity by 1985.

Table 2:4

Primary Fuel as a Percentage of Electricity Produced in Ontario

	Water Power	*Fossil Fuel*	*Nuclear*
1960	99.4	0.6	0.0
1970	60.5	37.8	1.7
1980	27.0	44.3	28.7
1990 M*	13.9	28.2	57.9
H**	13.9	14.4	71.7

*moderate nuclear program 1980 to 1990
**high nuclear program 1980 to 1990

THE ENERGY PATTERN IN CANADA

2:26 Energy use in Canada during the past two decades has been dominated by two related trends: a) the emergence of oil and gas in Alberta in the late 1940s and its availability east and west by the late 1950s; and b) the related displacement of coal first by oil and then by natural gas.

[3] About one-third of industrial consumption is accounted for by the primary metals and pulp and paper industries.

2:27 In absolute terms Canadian energy consumption increased from 2,560 trillion British thermal units in 1950 to 3,750 British thermal units in 1960, an increase of 46 per cent (3.9 per cent per annum). By 1970, total consumption reached 6,360 trillion British thermal units for an increase of 70 per cent over 1960 and an annual average rate of increase of 5.4 per cent.

2:28 This overview of the last two decades conceals some very important changes which were emerging towards the end of the period. These factors, as we shall see throughout the study, are gathering momentum in the early 1970s and will continue to influence energy supply and demand in Ontario, Canada and the United States for the next decade at least. Indeed, perhaps a new energy era is at hand.

2:29 Oil and gas will continue to dominate energy supply although giving ground steadily, especially to nuclear power. It should be emphasized that this decline in share of energy market for oil and gas conceals substantial absolute increases. The share of coal is expected to continue its decline for another few years, when technology and price relationships will bring about recovery. Coal consumption could double, bringing total demand back to the 1950 level. We have assumed continuing success of the CANDU nuclear system through the forecast period.

2:30 While there have been significant changes in Canada's energy supply pattern, there has been surprisingly little change in the nature of demand. The transportation sector dropped from 25 per cent to 20 per cent during the 1950s. This decline was largely due to the conversion of Canada's railroads to diesel power during the 1950s which greatly improved the efficiency of transportation energy use. Three of the four demand sectors experienced considerable gains in efficiency by moving from coal to oil and gas. The fourth sector moved in the opposite direction because of increasing thermal power generation at lower efficiencies.

Table 2:5

Canada Energy Demand by End Use 1950-1990

(Trillion Btu)

	Residential & Commercial	*Industrial*	*Transportation*	*Conversion Loss and Own Use*	*Total*
1950	735	700	655	470	2,560
1960	1,020	980	760	990	3,750
1970	1,660	1,615	1,220	1,865	6,360
1980	2,410	2,700	1,900	3,290	10,300
1990	3,300	4,400	2,800	5,400	15,900
			(Percentage of total)		
1950	28.7	27.3	25.6	18.4	100.0
1960	27.2	26.1	20.3	26.4	100.0
1970	26.1	25.4	19.2	29.3	100.0
1980	23.4	26.2	18.5	31.9	100.0
1990	20.7	27.7	17.6	34.0	100.0

Table 2:6

Canada Energy Supply 1950-1990

	Oil (million barrels)	*Natural Gas* (billion cubic feet)	*Coal* (million tons)	*Hydro* (billion kWh)	*Nuclear* (tons U_3O_8)
1950	126	70	46	50	–
1960	307	370	21	101	–
1970	518	1,165	29	150	–
1980	821	2,175	39	215	1,100
1990	1,100	3,200	60	300	2,700

(Percentage of total)

	Oil	*Natural Gas*	*Coal*	*Hydro*	*Nuclear*	*Other*	*Total*
1950	27.6	2.7	44.9	19.7	–	5.1	100.0
1960	45.9	9.9	15.2	26.9	–	2.1	100.0
1970	45.6	18.3	11.5	23.6	–	1.0	100.0
1980	43.0	22.1	9.0	20.2	5.5	0.2	100.0
1990	40.1	21.1	9.6	19.7	9.5	–	100.0

THE ENERGY PATTERN IN THE UNITED STATES

2:31 Any understanding of the energy outlook for the province of Ontario must be viewed against the overall Canadian and North American energy picture. If indeed there is an energy crisis of the 1970s, it originates in the United States and spreads from there through Canada to Ontario consumers. Some understanding, therefore, of the United States energy outlook, and how the various crises situations are likely to be met, is of great importance to the understanding of Ontario's position.

2:32 The pattern of energy consumption in the United States is not substantially different from Canada as a whole, and indeed from that of Ontario. In 1970, residential and commercial uses, principally space heat, were significantly below the Canadian and Ontario ratios, probably because of the obvious climatic difference. Industrial transportation and electrical utilities each accounted for roughly one-quarter of energy consumption.

Table 2:7

United States Energy Supply 1970-1980 (heat equivalent)

(Trillion Btu)

Domestic	*1970*	%	*1980*	%
Oil	21,048	31.0	24,323	23.7
Gas	22,388	33.0	18,600	18.1
Coal	13,062	19.3	19,928	19.4
Hydro	2,677	3.9	3,033	3.0
Nuclear	240	0.4	9,490	9.3
Geothermal	7	—	343	0.3
Sub-total domestic	59,422	87.6	75,717	73.8
Imports				
Oil	7,455	11.0	22,984	22.4
Gas	950	1.4	3,880	3.8
Sub-total imports	8,405	12.4	26,864	26.2
Total Demand	67,827	100.0	102,581	100.0

Source: *U.S. Energy Outlook, Volume II,* National Petroleum Council.

Table 2:8

United States Energy Supply (quantitative units)

	1970	*1980*
Oil (Million barrels per day)		
Domestic	11.3	11.8
Imports	3.4	10.7
	14.7	22.5
Gas (Trillion cubic feet)		
Domestic	22.0	18.0
Imports	1.0	4.0
	23.0	22.0
Coal (Million short tons)		
Domestic	519	799
Exports	71	111
	590	910
Electric Power (Billion kWh)		
Hydro	249	296
Nuclear	23	926
Geothermal	1	34
	273	1,256

2:33 United States energy consumption is expected to increase at an average annual rate of 4.2 per cent over the next decade. By far the strongest growth, as might be expected, will occur in the electric power sector with an average annual growth rate of about 7 per cent. By the mid-1980s, the electric utilities will require 35 per cent of the total energy supply.

2:34 In 1970, oil contributed 42 per cent of United States energy supply and natural gas 34 per cent. These ratios compare with 46 per cent and 18 per cent in Canada. Coal accounted for 19 per cent, while hydro, of significantly less importance in the United States, accounted for only 4 per cent in 1970.

2:35 Significant changes in United States energy supply are expected. In broad terms, the most dramatic change will be the greatly increased dependence on imports which are expected to account for 26 per cent of all United States energy by 1980.

2:36 Summarizing the supply situation, the domestic sources will decline from 87 per cent of total United States energy supply to 74 per cent. By 1980, the United States will rely on imported oil for approximately 22 per cent of its energy supply and imported natural gas for 4 per cent. The 1980 natural gas imports will come from Canada with significant volumes of liquefied natural gas coming from overseas resources.

2:37 Little increase in oil production from domestic sources is forecast in the United States. Therefore, the growth in demand must be met by a rapidly growing volume of imports. The United States is expected to double its dependence on imports within the decade of the 1970s and by 1980 will depend on imports for about half of total crude oil supply.

2:38 The situation for natural gas is considerably more serious. It is believed that United States domestic gas supply has already peaked, and a steady decline in production is expected. Offsetting this, imports will have to increase substantially, from just under one trillion cubic feet in 1970, to four trillion cubic feet in 1980. Combining the domestic and imported sources of gas, United States gas consumption would hold fairly steady at about 22 trillion cubic feet.

2:39 It should be noted that the role of imports could increase significantly for natural gas if supply were available. The United States natural gas outlook for the 1980s is entirely supply-conditioned, and demand forecasts are premised not on the basic requirements for gas, but rather on the availability of the product.

2:40 On the other hand, the United States is self-sufficient in coal and, indeed, has a surplus. Domestic coal production is expected to increase from 590 million tons in 1970 to 910 million tons in 1980. Exports are expected to increase from 71 million tons to 111 million tons during this period.

Energy Policy Implications

2:41 Perhaps the most important aspect of the United States energy outlook is the rapidly increasing dependence on imports. This applies to natural gas, crude oil and liquefied natural gas. It could extend to uranium if the nuclear breeder reactor does not succeed. Security of supply, therefore, is a major problem for the United States.

2:42 All indications point toward an inevitable sharp escalation of energy costs. This will be spread over all energy sources reflecting individual demand/supply relationships as well as interproduct demand transfers. The increasing role of imports will not materially improve energy costs, and indeed, in a reverse way, the supply problems of the United States will spill over into the Canadian and Ontario energy cost scene.

2:43 One seldom discussed aspect in the United States energy scene is the surprising degree of horizontal integration by energy companies. The long-term implications of this trend could be significant for energy prices.

Natural Gas

2:44 The principal problem facing the natural gas industry is the well-documented shortage of supply. Potential consumption will exceed supply by an increasing amount and will become more apparent through the decade. This may lead to increasing end-use controls and other consumer oriented measures.

2:45 Gas has traditionally been regarded as a by-product of oil exploration and, as such, an independent pricing philosophy has never been developed. Further, United States interstate gas prices have been controlled by the Federal Power Commission, essentially at 1950 levels. The result of these controls has been to encourage consumption of what has been called "cheap" gas, and to discourage exploration for new reserves. As a result, the United States is now down to about 11 years' gas supply.

2:46 With natural gas supply falling short of demand, the remaining energy sources will presumably share this unsatisfied market. This, in turn, will place increasing strains on the supply of these sources. Environmental factors have accented the gas supply shortage over the past five years and this element will increase in the decade ahead. One of the greatest indications of the magnitude of supply shortage in the Eastern Seaboard states is the recent willingness of United States utilities to accept North African liquefied natural gas as base-load supply.

2:47 Of direct significance to Canadian policy will be the possible dependence of United States gas supply on the Canadian energy "corridor". Frontier reserves of gas, either in Alaska or the Canadian Arctic, may be dedicated to a Canadian route.

2:48 Finally, the magnitude of United States gas demand enables the industry to absorb high-cost incremental supply with only nominal increases in average costs. This is in sharp contrast to the Canadian position based on a much smaller historical load, where high-cost incremental supply is "averaged in" much more quickly.

Petroleum

2:49 The increasing dependence on imports from the Middle East is a major issue. Indeed, the question of security of supply has received much attention in the United States and can be expected to be a major consideration in future oil policy development.

2:50 The United States oil consumption will also be greatly influenced by environmental considerations. The 1975 automotive emission controls could add 10 per cent to crude oil requirements. The shortage of natural gas, especially for industrial loads, will increase demand for residual oils. All this implies substantial cost and price increases.

2:51 In the short term, the United States faces a major refining capacity shortage[4], and implications of this for imports of Canadian crude oil could be significant. In other words, the United States might be compelled in the next few years to increase product imports at the expense of crude oil, although both are likely to increase substantially.

2:52 The Colorado oil shales present a technical, economic and ecological challenge for the next two decades. However, the United States federal government controls approximately 70 per cent of the shale leases and it is unlikely that any major thrust for development will come from the private sector.

Coal

2:53 The United States coal industry is being placed under great pressure to accommodate some of the impending energy deficiencies. Increased production for domestic use has been hampered by export demands, transportation, and lack of prices high enough to encourage the development of new production capability.

2:54 It is unlikely that major transportation improvements will be achieved in this decade, and some doubt has been cast upon the economic viability of long-distance slurry pipelines. The current emphasis seems to be on coal gasification, and the United States Government has been budgeting substantial amounts for research in this area.

ONTARIO ENERGY IN THE NORTH AMERICAN SETTING

2:55 Ontario consumption of energy in 1970 represented 37 per cent of the Canadian total; by energy source — 35 per cent of oil and gas, 69 per cent of coal and 29 per cent of hydro power.

Table 2:9

Energy Consumption by End Use - 1970

(Percentage)

	United States	*Canada*	*Ontario*
Residential/Commercial	20	26	26
Industrial	26	26	30
Transportation	24	19	17
Other	30	29	27
Total	100	100	100

[4]The United States will require the construction of 58 full scale refineries of 100,000 barrels per day capacity by 1980.

2:56 There is a close relationship between the United States, Canadian and Ontario energy economies. Similar supply sources, consumption patterns and technologies prevail. One major difference is the greater space heat requirements of Canadian markets.

2:57 This strong interrelationship could, however, be a major problem for Canada and Ontario in the next two decades through the spill-over of United States energy problems into Canada and more specifically into Ontario. The consumption orientation of Ontario's energy position makes it particularly vulnerable.

2:58 Ontario cannot have its own energy policy position directly with the United States; the province must rely on Canada's federal position. Ontario's energy economy will inherit the outcome of Canada-United States interactions in energy commerce.

2:59 Ontario's most direct energy tie with the United States is in the form of coal imports which account for the bulk of the province's coal supply. Historically, coal supplies from the United States have been most reliable in times of emergency and there is no reason to suspect that security of supply will deteriorate in the next decade – although domestic demand pressures on United States coal have increased substantially over the past few years. United States coal prices, on the other hand, are likely to increase steadily while the quality of coal deteriorates.

2:60 Ontario's oil and gas supplies are only affected indirectly by United States energy policies and principally through the influence of price. Availability of gas is protected by the National Energy Board on the basis of the exportable surplus calculations. The price of gas in Ontario also comes under National Energy Board scrutiny, at least from the viewpoint of pipeline charges. The price of gas in Ontario will, in the long run, be influenced by the scale and cost structure of the United States market.

2:61 Ontario's oil supply, coming principally from Alberta, is removed directly from United States energy policy. If no new conventional reserves are added in the next few years, then Canadian crude oil exports will probably come under the review of the "exportable surplus" rule thereby increasing the contact with United States federal energy policies.

2:62 There is the question of nuclear power – or more specifically, uranium. Removal of the United States embargo on uranium imports could increase the demand for Ontario ore. When the present surplus of uranium has disappeared, caution may be necessary in the disposition of large uranium export permits.

Chapter 3

Ontario's Indigenous Energy Resources

INTRODUCTION

3:1 As the major energy consuming region in Canada, the availability of indigenous energy resources in Ontario is of strategic significance. In recent times the province has been heavily dependent on imported energy although in the late nineteenth century the province had an exportable surplus of oil and gas, shipping some products as far as Europe.

3:2 In 1970 the province imported approximately 80 per cent of its energy requirements. Local production of petroleum and natural gas make up about one per cent of the total energy supply and the contribution of uranium through nuclear power is beginning to be significant. The most important local energy source, however, is water power which in 1971 was still the major source of electric power generation in Ontario.

3:3 Little change in the relative provincial contribution to total supplies is expected, with the increasing nuclear role merely offsetting the declining role of water power in the total generating system. By 1990, however, indigenous energy resources should account for one-quarter of the province's needs, largely in the form of uranium fuel.

PETROLEUM AND NATURAL GAS

3:4 In 1858, James Miller Williams dug to a depth of sixty feet at Oil Springs, Lambton County, and completed North America's first recorded oil well. Since that time oil production from the oil fields in southwestern Ontario has totalled close to fifty million barrels. The natural gas industry in Ontario came into being thirty years after the first discovery of oil. In most of the oil fields, gas had initially accompanied the oil, but with the equipment at hand, no attempt was made to control its flow.

3:5 Natural gas in commercial quantities was not discovered in Ontario until 1889, when a successful gas well was drilled in Essex County near the town of Leamington. This well had an initial open flow of ten million cubic feet of gas per day and represented the discovery well of the Kingsville field. During the same year, a second discovery well was drilled six miles east of Port Colborne on the Niagara Peninsula. This latter well was the beginning of the Welland field. These two fields, some 200 miles apart, were quickly developed, and gas was exported to Detroit, Toledo and Buffalo. As it became apparent that ready markets awaited the discovery of new fields, much prospecting quickly followed, resulting in the Haldimand field discovery of 1891 and in 1906 one of the largest and most important Ontario discoveries, the Tilbury field.

3:6 By the early 1900s, Ontario was not only self-suffiicent in oil and gas but was a net exporter of energy. Over the years, however, as the Ontario economy continued to grow, local resources became inadequate and American coal became the predominant energy source. Local oil and gas resources levelled off as a small but significant component of the total supply.

3:7 During the past decade, the number of wells drilled in Ontario has been about 200 per year. Of this total, an average of 36 wells per year have been drilled in Lake Erie. In 1971, activity was below average but 160 wells were drilled of which 64 were exploratory wells and 66 development wells. Exploratory wells have averaged about a 15 per cent success rate. The total footage drilled was 290 thousand feet, so that the average well drilled in Ontario is under two thousand feet.

3:8 Until very recently, the land drilling has been carried out by cable tool rigs. Cable tool equipment, although slower, costs less than rotary equipment, requires less manpower and is more economical for shallow drilling. The recent increase in rotary drilling equipment has curtailed the activities of all but a few cable tool operators. With rotary rigs, a two thousand foot well may be drilled in five days whereas a cable tool rig may take up to five weeks to complete a similar well. Exploration and development is carried out by several independent operators and the two southern Ontario gas utilities.

3:9 Over the past decade, oil production has averaged just over one million barrels per year. By assuming a continuing annual production rate of one million barrels and no future development, proven remaining oil reserves would be exhausted by 1980. However, by projecting the oil discovery rate of three pools per year, based on the last ten years' experience, 30 additional oil fields

may be expected to be discovered in the next ten years. Accordingly, oil production in southwestern Ontario is expected to remain about the one million barrels per year mark.

Table 3:1
Summary of Drilling[1] - 1971

	Exploratory					Development				
	Number of Wells Drilled				*Footage Drilled (000)*	*Number of Wells Drilled*				*Footage Drilled (000)*
County	*Gas*	*Oil*	*Dry*	*Total*		*Gas*	*Oil*	*Dry*	*Total*	
Elgin	2		9	11	13.8	8		8	16	29.7
Haldimand						3		1	4	3.0
Kent	1		6	7	23.0			5	5	11.9
Lambton	2	1	29	32	65.5	5	2	7	14	29.7
Lincoln						3			3	1.6
Middlesex			6	6	8.8			1	1	3.6
Norfolk	4			4	5.8	13		6	19	29.9
Other		1	3	4	11.7	2		2	4	6.4
Totals	9	2	53	64	128.6	34	2	30	66	115.8

[1]Not included are 30 other wells with 44,807 footage.

Table 3:2
Oil Production by County 1971

County	*Barrels (000)*	*Percentage*
Brant, Oxford	60	6.3
Elgin	476	49.7
Essex	12	1.3
Kent	62	6.4
Lambton	323	33.7
Middlesex	24	2.5
Others	1	0.1
	958	100.0

3:10 Natural gas production has remained relatively constant over the past decade at 15 billion cubic feet with the wells in Lake Erie accounting for four to five billion cubic feet. An average of nine new gas pools per year have been discovered in southwestern Ontario over the past ten years. This development is expected to continue and the present production rate of about 15 billion cubic feet per year to be maintained.

Table 3:3

Gas Production by County 1971

County	*Million Cubic Feet*	*Percentage*
Elgin	1,007	6.2
Essex	416	2.5
Haldimand	889	5.5
Kent	2,687	16.6
Lambton	8,238	50.9
Norfolk	1,798	11.2
Oxford	148	1.0
Welland	820	5.1
Other	165	1.0
	16,168	100.0

3:11 The recorded cumulative production from Ontario oil and gas fields is approaching 50 million barrels of oil and 760 billion cubic feet of natural gas. Proven remaining recoverable reserves have been established at 11 million barrels of oil and 253 billion cubic feet of natural gas. All proven oil and gas reserves lie exclusively in southwestern Ontario. Sixty per cent of present yearly production comes from pools utilizing secondary recovery techniques, mainly waterflood. Several units developed in the early years of the industry were damaged by improper completion and production practices with the resulting loss of secondary recovery from these units.

Table 3:4

Ontario's Proven Recoverable Oil and Gas Reserves

	Proven Reserves (Primary)	*Proven Reserves (Secondary)*	*Production to Dec. 31/70*	*Remaining Recoverable Reserves*
Oil (million barrels)	46.9	12.3	48.1	11.1
Gas (billion cubic feet)	986.1	—	733.4	252.7

Potential Reserves

3:12 The Ontario Ministry of Natural Resources has calculated potential oil and gas reserves for southwestern Ontario, one of the two areas of the province considered to have commercial production potential. The Ministry has assigned figures of 280 million barrels of oil and four trillion cubic feet of gas as remaining potential oil and gas reserves in the area (the land portion of southwestern Ontario plus adjacent parts of the Great Lakes). Exclusion of estimated potential under the Great Lakes and Lake St. Clair (where all drilling for oil is prohibited) reduces the remaining potential figure for oil to 144 million barrels. Exclusion of the Great Lakes and Lake St. Clair, except for Lake Erie, reduces the remaining potential figure for gas to 3.84 trillion cubic feet of which two trillion cubic feet are attributed to Lake Erie.

3:13 In estimating the reserve potential of southwestern Ontario, the Ministry defined the extent (in cubic miles) of the zones with oil and gas-bearing potential, by geological formation, for each of the two sedimenary basins (the Appalachian and the Michigan) in the area. A potential recovery factor for each geological formation was calculated and applied at the rate of 20 thousand barrels of oil per cubic mile of sediment and fifteen thousand cubic feet of gas per barrel of oil. These are in line with the figures applied by the Canadian Petroleum Association but the Ministry and the Association do not agree on the estimated rock volume for the basins.

3:14 Northern Ontario embraces two sedimentary rock basins known as the Hudson Bay Basin and the Moose River Basin. Recently the Canadian Petroleum Association assigned a total volume for both basins of 145 thousand cubic miles. At least 130 holes have been drilled in the rocks of the Moose River Basin in the search for minerals as bedrock tests and, in a few cases, for hydrocarbons. No economic occurrences of hydrocarbons have yet been encountered but the geology of the region is considered favourable for both oil and gas. Currently, 6½ million acres is held under licence by 3 companies and three exploratory wells were drilled during 1971. Potential reserves are based on recovery factors of ten thousand barrels of oil per cubic mile and ten thousand cubic feet of natural gas per barrel of oil because of the similarity to the Michigan sedimentary basin. The development of reserves, however, is virtually unpredictable because of the limited drilling history to date.

NATURAL GAS STORAGE

3:15 As a result of 80 years of natural gas production, there are a number of depleted gas reservoirs in southwestern Ontario. They continue to play an important role in our energy supply chain, however, as temporary storage areas for off-peak or "valley" gas from western Canada. The depleted gas reservoirs allow the gas distributors to take delivery of gas, inject it into the reservoir and recover it during periods of peak demand. The two thousand mile pipeline facilities are thereby able to be used with maximum efficiency.

Table 3:5

The Ontario Natural Gas Supply Pattern

(Billions cubic feet)

Year	*Ontario Production*	*Imports from* U.S.A.	*Imports from* Western Canada	*Storage Withdrawals Cycle Ending Mar. 31*
1960	17.0	5.5	89.4	8.9
1965	12.6	17.6	229.5	31.1
1970	16.6	10.7	463.8	64.6

3:16 To be effective, reservoirs utilized for gas storage must have the ability to deliver the gas at high rates in order to meet the extremely heavy demands placed on the utility on peak days and hours. The storage in Ontario is very favourable in this regard as the reefs are both porous and highly permeable. Thirty-seven of these reservoirs are now being used.

3:17 In Ontario, all underground storage activities are conducted by the two major distributors – Union Gas Company and The Consumers' Gas Company, who are in a geographical position to take advantage of storage reservoirs in southwestern Ontario. TransCanada PipeLines, the major supplier to these two distributors, does not operate storage directly in Ontario but gains considerable benefit indirectly through interruptible service contracts with Union and Consumers'. This type of contract provides to TransCanada most of the benefits that would be realized by pipeline from storage at point of use.

3:18 The principal benefit of storage to the distributor is the ability to store valley gas and to return that gas to the market at a time when it can be used to supply the peak demands of the space heating market. The distributor is thus able to buy at the most advantageous price and to sell those purchases effectively in the premium market. A substantial benefit is also gained by the flexibility which storage provides in the distributor's marketing pattern. With storage it is not necessary to match the marketing pattern to he purchase pattern from the pipeline, thus enabling the distributor to provide better service to many industrial consumers. A secondary benefit is the distributor's ability to purchase spot sales of overrun gas when they become available from the pipeline, at advantageous prices.

3:19 There are an adequate number of suitable storage reservoirs available in southwestern Ontario to meet the foreseeable need of distribution in the southern part of the province. The more recent discoveries also provide excellent potential storage capacity. Partially depleted reservoirs beneath Lake Erie represent additional potential for storage but the increased costs in developing these reservoirs make them less attractive than those in the Lambton County area.

3:20 The Consumers' Gas Company has conducted an evaluation of aquiferous gas storage in the Ottawa area but results were not encouraging and the pilot project has been terminated. In northern Ontario, where no natural storage is available, the Northern and Central Gas Corporation Limited has resorted to above-ground storage of liquefied natural gas. The Hagar plant has a capacity of 550 million cubic feet per year and is used to provide peak-shaving gas, particularly for the heavy industrial loads of the Sudbury area. The Hagar plant may possibly be doubled by 1980 to keep pace with the requirements of the system.

STORAGE OF LIQUIDS AND PRODUCTS

3:21 In addition to the present storage of natural gas in depleted natural gas reservoirs, the very favourable geological conditions in the Sarnia area have led to the development of salt cavern storage for other products.

3:22 These salt beds have been utilized as a source of salt since their discovery in the Goderich area in 1866. Since the early 1950s, however, the caverns have been washd out for purposes of storage. The caverns range in capacity from 50 thousand to 600 thousand barrels. At the present time, six companies are operating salt caverns for storage purposes in the Sarnia area.

3:23 The advantages of subsurface storage are significant as comparative surface storage costs range from twice to more than twenty times the cost of developing salt caverns, depending upon the nature of the product to be stored and the operating pressure. In addition to the cost factor, cavern storage offers considerable operational flexibility and safety. At the present time each of the refineries utilizes salt cavern storage as an integral part of its operation.

3:24 Three caverns of approximately 200 thousand barrels capacity are presently in use for storing the unprocessed natural gas liquids received from Interprovincial Pipeline. One cavern is under development and two more are projected for development for a total capacity of 1,200 thousand barrels. Nine product caverns having capacities of 180 thousand to 200 thousand barrels are being developed for storage of propane and butane. It is probable that further storage capacity will be required in both the Sarnia and Windsor areas.

LIGNITE

3:25 Ontario's known coal resources are limited to a deposit of lignite in the northern part of the province. The deposit, located at Onakawana in the Moose River Basin, has been estimated to contain a minimum of 170 million tons of mineable lignite. The Onakawana deposit is in a potentially coal-bearing basin of large extent, bounded in an east-west direction by the Kesagami and Kenogami Rivers — a distance of some 215 miles. The basin, delineated by occurrences of lignite reported over the past century, has not been systematically explored. Accordingly, the potential for significant extensions still exists.

3:26 Lignite, generally defined as having a moist mineral-matter-free heat content of up to 8,300 Btu per pound, and a moisture content varying from 20 to 60 per cent, is a major fuel in some European countries. Annual Canadian production of some 3.5 million tons, primarily from Saskatchewan, is used mainly for generation of electrical power.

3:27 A number of attempts to determine the feasibility of developing the Onakawana deposit have been made. A drilling program, begun in 1929, was followed by sinking of shafts and extensive testing of samples. Operations were stopped by 1932 because of economic conditions. In 1941, a pilot program of strip mining to provide lignite for testing on locomotives and stationary equipment was started. A Select Committee of the Ontario Legislature received results of the program in 1945 and concluded that development of the deposit was not economically sound at that time. Since 1967, the Alberta Coal Company has been carrying on exploratory work under licence. Its program has included recent burning tests of one thousand tons of lignite at Ontario Hydro Thunder Bay thermal plant.

3:28 Onakawana lignite is rated at 5,340 Btu per pound and has a moisture content of 48.13 per cent. Its heating value is thus in the same range as the brown coals extensively used for power generation and industrial and home heating in central Europe. The great bulk of the four million tons of lignite mined in the United States and the 3.5 million mined in Canada are of considerably higher grade (a net calorific value of close to seven thousand Btu per pound and a moisture content of 30-35 per cent). However, lignite from one location in North Dakota, with a calorific value of six thousand Btu and a moisture content of 38-39 per cent, is being used to generate electric power. Onakawana lignite was tested by the Fuels Research Centre of the federal Department of Energy, Mines and Resources in 1968-1969. It was concluded that "while Onakawana lignite is a low-grade energy resource, it is better than many in use throughout the world, and there appear to be no technical obstacles to its utilization that research and sound engineering cannot overcome."

3:29 Onakawana lignite, viewed over the longer term, appears to have potential as feed for an on-site thermal power development, or as a source of pipeline gas, a possibility which has recently been investigated by the Ontario Research Foundation. It was concluded that gasification of the Onakawana deposit will be technically and economically feasible within five to twelve years, if experimental testing confirms suitability, particularly in respect to low-ash fusion temperature. The Foundation report also considers that from the energy utilization viewpoint, gasification would be preferable to using the deposit as feed for a thermal power generating plant, since almost twice as much usable energy per ton of lignite is produced. The TransCanada PipeLines system passes within 150 miles of the deposit.

HYDRO SITE POTENTIAL

3:30 Since the turn of the century, six million kilowatts of hydro-electric capacity have been developed in Ontario. Under present economic conditions, and given Ontario Hydro's current operating characteristics, additional sites aggregating about 1.5 million kilowatts may have economic potential, mainly for peaking power, but not before 1978. Some further potential may also exist for pumped storage peaking capacity.

3:31 The economics of developing hydro sites are usually derived by drawing comparisons with the cost of developing equivalent fossil-fired capacity. These comparisons are sensitive to the prevailing rate of interest on borrowed funds, construction costs, escalation of prices on labour and materials, and on the prices of fossil fuels. In addition, Ontario Hydro's past studies have tended to show that, provided transmission costs are not excessive, hydraulic sites are most likely to be economic if they are developed at a low capacity factor.

3:32 Of the sites considered most attractive for development – some time after 1978 – three are on the Mattagami River, and are all extensions to existing plants. The Harmon and Kipling extensions each have a capacity of 140 thousand kilowatts. The Little Long extension is rated at 125 thousand kilowatts.

3:33 Extensions to the Des Joachims Generating Station on the Ottawa River, totalling as much as 600 thousand kilowatts, are considered to be economic. However, relative attractiveness increases with scale, and any development undertaken would likely have to be on a large scale.

3:34 Two undeveloped sites totalling 113 thousand kilowatts lie on the White River. These sites are located in Ontario Hydro's West System, and are not desirable for development until an additional high-capacity factor thermal plant has been installed. Thus, development is not likely to occur for some time, from the point of view of power economics. Of more significance, development may be completely ruled out by proximity to the new Pukaskwa National Park.

3:35 Two sites on the Little Jackfish River, with a combined capacity of 140 thousand kilowatts, are considered economic at an interest rate as high as eight to nine per cent. However, cost of transmission weighs heavily against these developments. High transmission costs are also a factor in the development of Long Sault Rapids on the Abitibi River where a plant size as large as 110 thousand kilowatts may be economic.

3:36 Other marginal sites are Gros Cap on the Mississagi River and Highland Falls on the Madawaska River which offer the possibility of peaking plants with installed capacities of 270 thousand kilowatts and 90 thousand kilowatts respectively. However, additional capacity of this kind will not likely be required by Ontario Hydro in the near future.

3:37 Two peaking power-pumped storage sites are considered as development possibilities over the long-run. Development of these sites — Delphi Point with capacities of 1 to 2 million kilowatts and Jordan with potential of several million kilowatts will depend upon the availability of low-cost nuclear generating capacity during off-peak periods.

3:38 A number of rivers emptying into the Hudson and James Bay may have long-run development potential, but most likely only for generation of power to be used locally. Among rivers in this category are the Moose, the Severn and the Albany.

URANIUM

3:39 The first known reference to uranium in Canada was made more than 100 years ago in northern Ontario. This early reference stimulated prospecting after the Second World War which led to the major discoveries in the Elliott Lake-Blind River district. By 1957, this district had become the most important uranium mining area in Canada. Additional but lower grade deposits were also developed in the Bancroft area at the same time. At the peak of the Canadian uranium boom in the late 1950s, there were 23 producing mines in Canada with an annual output of close to 31 million pounds. Total Canadian production of U_3O_8 exceeds 200 million pounds valued at more than two billion dollars.

3:40 For more than a decade, annual production has been low and production has been maintained by means of a federal government stockpiling program. Under two successive uranium stockpiling programs, 9,500 tons of

U_3O_8 were purchased at a cost of about $100 million. A third agreement covers the production of 3,176 tons U_3O_8 to be delivered through 1974. However, in recent years, several new contracts for delivery of Canadian uranium to foreign countries have been signed. Ontario Hydro has contracted to purchase 7,500 tons of U_3O_8 over the next ten years.

3:41 Only three companies are now producing uranium in Canada and two of these are located in Elliott Lake. Production totalled 4,580 tons in 1970 and 4,976 tons in 1971, of which 85 per cent came from the Elliott Lake district. Canadian production made up 21 per cent of world production.

3:42 The most productive type of uranium deposits in Canada are the quartz-pebble conglomerates that occur in the Elliott Lake-Blind River area. More than 80 per cent of the Canadian reasonably-assured reserves are found here. Significant production has also been obtained in the past from pegmatitic deposits located in the Bancroft area.

3:43 Any ore reserve, by definition, is capable of supporting profitable production at a given price. It has become customary in the uranium industry to quote reserves on the basis of a price up to ten dollars per pound of U_3O_8; that is, to include in reserves all uranium deposits from which it would be economical to produce uranium at a price up to ten dollars per pound of U_3O_8.

3:44 It has been estimated that 232 thousand tons of U_3O_8 can be produced at prices up to ten dollars per pound.

Table 3:6

Uranium Reserves and Resources in Canada 1970

Price Dollars per pound	*Reasonably Assured Resources (Reserves)*	*Estimated Additional Resources*
	(Thousand of short tons U_3O_8)	
Under 10	232	230
10 - 15	130	170

3:45 The known uranium reserves of the world (exclusive of the Soviet Bloc countries) estimated to be producible at prices not exceeding ten dollars per pound of U_3O_8 are summarized in the table that follows.

3:46 At present, the uranium mining industry is operating considerably below capacity, due primarily to a buildup in the late 1960s to meet a demand which has not developed at the expected rate. For the past three years, world production exclusive of the Soviet Bloc countries, has been under 25 thousand tons U_3O_8 per year. Substantial stockpiles and inventories exist among the world's uranium producers including 50 thousand tons held by the United States Government and about ten thousand tons held by the Canadian Government.

3:47 The United States maintains an embargo on the domestic use of imported uranium enriched in the United States diffusion plants, and it is considered unlikely that this will be lifted in the near future. If the United States embargo

is lifted, then Ontario's reserves should be called into a high level of production by about the end of the 1970s. If the embargo is not lifted, then demand may be delayed for two to three years. In any case, world demand is expected to grow rapidly through most of the 1980s.

Table 3:7

Uranium Ore Reserves - 1970
At Prices Not Exceeding $10 Per Pound

Country		*Ore Reserve Thousands of short tons of U_3O_8*	%
Canada:	Ontario	190	19.8
	Other	40	4.2
	Subtotal	230	24.0
Argentina		10	1.0
Australia		100	10.4
France and Former French Africa		100	10.4
Portugal and Angola		10	1.0
South Africa & South West Africa		200	20.8
Spain		10	1.0
United States		300	31.3
	Total	960	100.0

3:48 Although Ontario's current known reserves of 190 thousand tons of U_3O_8 are large in comparison to world 1972 demand of 21 thousand tons, they become much less significant when compared to the expected annual demand in the mid 1980s of an estimated 140 thousand tons.

3:49 Many countries are expected to have large nuclear power programs and accordingly the world demand for uranium is expected to outrun the supply. Substantial new production facilities will be required and the provision of these facilities will require relatively long lead times:

(a) Between six and ten years before the production date, exploration for uranium must be commenced.

(b) About five years before the production date, a mineral deposit must be discovered.

(c) About three years before the required production date, the reserve must be sufficiently well delineated to allow a firm production decision to be made.

3:50 Best current estimates indicate that the United States will not be able to meet its own requirements from domestic production facilities within the present decade. Similarly, in other producing countries, new facilities based on

reserves yet to be discovered will be needed around the end of the present decade. In other words, renewed exploration for uranium on a substantial scale is required now. However, the industry, with soft current markets has no immediate incentive to explore.

3:51 Canadian producers have been relatively successful in obtaining contracts for forward sales, and these, in conjunction with the federal government's stockpiling program, will help producers over the short-term period of depressed markets. However, when demand for uranium, outside the United States, increases rapidly in the late 1970s, these existing producers will quickly become fully committed, and additional productive facilities will be required to meet demand in the United States and other parts of the world.

3:52 Oustanding contracts for Canadian uranium for delivery during the next ten years now total over 60 thousand tons U_30_8.

THORIUM

3:53 As with uranium the largest part of the Canadian thorium reserves are found in the Elliott Lake conglomeratic ores. Thorium is also present in the pegmatitic ores of the Bancroft area.

3:54 The market for thorium has been limited, although small quantities of $Th0_2$ have been produced as a by-product of the uranium operations at Elliott Lake.

3:55 It is estimated that reasonably assured thorium reserves associated with uranium exceed 100 thousand tons $Th0_2$. Further, because the thorium is received as a by-product of the uranium operations, the price should make it competitive in world markets when these appear. It will be remembered that thorium is expected to be one of the fuels used with the advanced thermal and fast reactors.

Chapter 4

External Factors Affecting the Ontario Energy Supply

WORLD PETROLEUM TRENDS

4:1 Oil is one of the most strategic energy commodities in world trade. This is based not only upon the volume of oil which moves between producing countries and consuming countries, but also on the fact that petroleum currently accounts for 52 per cent of world energy consumption. By 1980, this ratio is expected to increase to 58 per cent. This implies an average annual increase of 6.5 per cent per annum in world oil consumption over the next decade. In absolute terms, this is an increase from 40 million barrels per day to about 73 million barrels per day by 1980.

4:2 Between 1970 and 1980, the world will consume approximately 200 billion barrels of oil – roughly equivalent to total world consumption to date and about 40 per cent of known oil reserves, North America, Western Europe and Japan accounting for 80 per cent of the total world consumption.

4:3 In 1960, 70 per cent of the world's crude production came from western hemisphere countries. By 1970 this percentage was 45 per cent, and by 1980 it is estimated that only 30 per cent of world oil supply will originate in the western hemisphere. Currently North America produces about one-third of the

world's oil. This contribution will probably decline to approximately one-fifth by 1980, while the Middle East countries should increase their contribution from 34 per cent currently, to 40 per cent by 1980.

4:4 Western Europe is one of the world's largest oil consuming markets, and in 1970 was almost totally dependent on imports of oil, principally from the Middle East and Africa. During the 1960s, however, substantial crude oil reserves were proven in the North Sea, and development of these reserves should enable Western Europe to become less dependent on imports. This is estimated to range from 20 per cent to 30 per cent by 1980. This assumption is based upon North Sea production in 1980, ranging from 4 million to 6 million barrels per day which is three to four times current Canadian production.

4:5 Japan is wholly reliant upon imported petroleum, and is likely to remain so. This dependence is of great strategic significance to Japan and will become increasingly so as the Japanese economy grows at above average rates over the next ten years. The implications for Japanese planning will probably lean heavily towards nuclear power. In terms of petroleum supply, growing imports from Indonesia will partially reduce Japan's dependence on the Persian Gulf sources.

4:6 Between 1960 and 1970, North America relied on imported oil to satisfy about 20 per cent of demand for petroleum. Including anticipated production increases in Canada and production from the Alaska North Slope, North America's import dependency is expected to increase to 35 per cent by 1980. This North American overall dependency, however, should not conceal the substantial difference in the position of Canada and the United States. The United States import dependence position in 1980 will be about 47 per cent of all oil consumption. Offshore imports (that is, from non-North American sources) will be less than 36 per cent because of the contribution of Canadian exports to United States crude oil shortages.[1]

4:7 Currently, 75 per cent of oil imports into North America come from western hemisphere sources. By 1980, however, this ratio will be reduced to 40 per cent, the remaining 60 per cent coming from the eastern hemisphere, principally the Persian Gulf. The increasing United States import dependency over the 1970s has substantial political and economic implications but it is unlikely that any United States energy policy changes in the next few years can appreciably affect this overwhelming fact.

4:8 An estimated 67 per cent of all conventional oil reserves are located in the Middle East and the world will rely more and more heavily on production from this source. The life index for world oil (i.e., reserves divided by annual production) is currently approximately 38 years. Assuming a continuation of past trends, however, this life index is likely to drop to about 20 years by 1980. By comparison, the United States reserve life index is currently (1970) 10 years and Canada's life index 23 years. In other words, the weight of world consumption

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[1]Canada's imports may be reduced by the availability of offshore coast production — possibly 200,000 barrels per day by 1980.

of oil will, over the 1970s, bring down the currently high life index ratios for overall world consumption, to the present lower ratios of the two North American consumers.

Table 4:1

World[2] Oil Reserves - 1970

	Reserves (Billion barrels)		*Production* (Million barrels per day)		*Life Index* (Years)
		%		%	
Middle East	346	67	13.6	36	69
Africa	75	15	6.0	16	34
Latin America	26	5	5.1	14	14
U.S.A.	37	7	9.5	25	10
Canada[3]	11	2	1.3	4	23
Far East	14	3	1.4	4	27
Europe	4	1	0.4	1	28
Total	513	100	37.3	100	38

4:9 Over the past two years there has been a growing awareness in the United States of the increasing dependence on Middle East petroleum. Additional producing capacity in the United States has been largely exhausted, and the reserve life index has been dropping steadily. As a result, the future focus of oil in international energy trade lies in the location of world oil reserves. As noted above, 67 per cent of proven conventional reserves (excluding the Soviet Bloc) are located in the Middle East. Four countries – Saudi Arabia, Iran, Kuwait and Iraq – control about 63 per cent of the world's reserves, or some 324 billion barrels. Furthermore, in these countries three specific fields hold approximately 170 billion barrels, or 32 per cent of total world reserves. Against this dominating role in world oil reserves, the Middle East currently accounts for only 36 per cent of annual crude production. This clearly indicates the longer-term significance of Middle East oil vis-a-vis the diminishing ratios of the world's principal consuming areas. The middle East currently has a life index of 69 years compared with the world oil life index of some 38 years.

4:10 It has long been assumed that the world has unlimited oil resources. Over the past two decades, the volume of reserves related to current production levels encouraged this complacency. But as the rate of consumption increased, the reserve ratio declined – and this trend is expected to accelerate.

4:11 Offsetting this trend is the volume of new discoveries – currently averaging about 29 billion barrels per annum. The continuation of this trend would result in 290 billion barrels over the decade. Adding this to current

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[2]Excludes Reserves in U.S.S.R. (77 billion barrels) and China (20 billion barrels).

[3]Does not include tar sands or heavy crude oil such as Cold Lake, estimated at 300 and 50 billion barrels, respectively.

reserves of 510 billion barrels and assuming consumption of 200 billion barrels, 1980 remaining reserves would be 600 billion barrels, or 22 years at the estimated 1980 consumption level of 72 million barrels per day. This is still a comfortable margin, but down substantially from the current level of 38 years' supply.

4:12 Extending this exercise to 1990, consumption in the 1980s will require 370 billion barrels and exploration could add another 290 billion barrels of new oil, indicating a 1990 reserve position of 520 billion barrels. At an estimated production rate of 130 million barrels per day, the world oil life index would drop to 11 years.

4:13 By 1990, therefore – or in any event before the end of this century – the world will be faced with the necessity of greatly increasing oil discovery rates or curtailing consumption. Both solutions will be necessary, particularly in offshore development and increased substitution of nuclear power. The role of nuclear power has been slow in developing and a considerable acceleration will be needed by the 1980s if the world oil shortage is to be offset.

4:14 Worldwide energy costs have remained relatively stable over the last two decades. The price of Alberta crude oil delivered to Ontario refineries was about the same in 1970 as in 1951 – about 56 cents per million Btu. Ontario has been partially insulated from world oil price factors by the National Oil Policy which restricts imported oil to eastern Canada, including the Ottawa Valley of Ontario. This policy may have had the effect of increasing Ontario crude oil costs in some areas by as much as 9 cents per million Btu which could be regarded as a "security of supply" premium. As will be developed later, world prices (principally Middle East) are closing the gap with North American (Ontario) prices.

4:15 During the early 1960s, world oil prices actually declined under the weight of supplies from prolific new sources such as Libya and Nigeria. Low tankers rates also contributed to lower landed costs in North American markets. By the end of the decade, however, the combination of strengthening demand and impaired supply emerged. Demand accelerated for all forms of energy – worldwide. Europe and Japan emerged as major demand centres – both energy deficient and largely dependent on the same Middle East supply sources.

4:16 On the supply side, the 1967 closure of the Suez Canal greatly reduced the deliverability[4] of the world's tanker fleet, driving up tanker rates and landed costs of Middle East crudes. These in turn set new values for North African and Venezuelan crude oils. Of greater long-term significance, the effect of this supply stringency on major markets demonstrated to the Middle East producers their strength and market influence. This new awareness has since been reflected at the bargaining table, as a result of which the Organization of Petroleum Exporting Countries (OPEC) has succeeded in establishing significantly higher prices for crude oil.

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[4]By diverting tankers around Africa, annual carries delivered tonnage was reduced. This encouraged construction of VLCC's (very large crude carriers, i.e., 200,000 DWT plus) which had not been able to use Suez. These vessels reduced shipping costs substantially and are now a major factor in tanker trade.

4:17 The scope of these negotiated increases can be seen:

Table 4:2
Additional Government Revenue
(Cents per million Btu)

	1970 and 1971	*1972 to 1975*
Middle East	6.7	3.7
Libya	15.6	2.4
Venezuela	8.1	*

*Variable with crude prices which are set by the government each year.

4:18 The total average increase for the Middle East would be about 16 cents per million British thermal units plus a United States dollar devaluation factor. OPEC are now negotiating for participation with the companies operating in their countries. While this may lead to higher prices, it could stabilize production.

4:19 As a result of these combined demand-supply factors, world energy costs began to increase. Canadian and United States domestic crude oil prices increased by about four cents per million British thermal units between 1970 and 1971. These are however substantially lower than the OPEC increases.

A REVIEW OF CANADIAN ENERGY RESOURCES

PETROLEUM

Production

4:20 The province of Alberta has dominated petroleum production in Canada since the 1950s. In 1955, the province accounted for 87 per cent of total available production, with Saskatchewan the only other significant province producing 9 per cent. Today, Alberta continues to produce about 80 per cent of all Canadian production. Production in Saskatchewan levelled off in the 1960s at just below 250 thousand barrels per day. Saskatchewan produces 14 per cent of the Canadian total. British Columbia fields produce about 75 thousand barrels per day, 4 per cent of the Canadian total. Ontario no longer contributes significantly to Canadian crude production and the ratio has declined from 0.5 per cent in 1960 to an estimated 0.2 per cent in 1972. Ontario production remains steady at about three thousand barrels per day.

4:21 In 1960, about 20 per cent of Canadian oil production was exported to the United States. By 1971, this ratio had reached 50 per cent and is expected to continue to increase. The greatest growth has been to United States markets east of the Rockies which now account for about 40 per cent of Canadian production. Markets on the West Coast have increased fivefold in absolute terms from 1960 to 1972, and now account for more than 14 per cent of total Canadian production.

4:22 The outlook for Canadian oil exports to the west coast of the United States became uncertain with the proposal to build the Alyeska pipeline from the North Slope of Alaska. The continual deferral of this project, however, has added several years to the life expectancy of major exports of Canadian crude oil to the Pacific northwest states. In any event, with the anticipated rates of increase in demand for crude oil from the whole of the United States Pacific Coast even including the two million barrels per day from the North Slope, it is likely that Canadian exports of oil to this area will continue at a high level. Exports of both oil and gas account for nearly half of total Canadian production. In both cases these volumes supply less than 5 per cent of United States requirements. This is of particular significance when the price influences of frontier resources are discussed.

Table 4:3

Canadian Exports to United States - 1970

Oil	
Canadian exports to the United States (MB/D)	659
As Percentage of total production	48%
As percentage of United States oil requirements	4.5%
As percentage of United States oil imports	19%
Gas	
Canadian exports to the United States (BCF)	777
As percentage of total production	46%
As percentage of United States gas requirements	3.5%
As percentage of United States imports	84%

Self-sufficiency

4:23 One of the key oil policy issues is security of supply, and one of the principal aspects is the self-sufficiency ratio. This relates total consumption of crude oil to domestic production available.[5] The self- sufficiency factor for Canadian oil has improved from 56 per cent in 1950, to 98 per cent as estimated for 1971. The outlook for 1972 suggests that the ratio should pass the 100 per cent mark for the first time, with net exports exceeding net imports.

4:24 This improvement is based upon the rapid expansion of exports of crude oil to the United States which has enabled domestic crude production to increase sharply. Domestic crude has increased from 357 thousand barrels per day in 1955 to an estimated 1,655 thousand in 1972. Refinery receipts of crude oil have increased from 537 thousand barrels per day in 1955 to an estimated 1,515 thousand in 1972. Meanwhile, net product imports jumped from 100 thousand barrels per day in 1955 to 182 thousand in 1970, but are estimated to drop back to 80 thousand barrels per day in 1972.[6]

[5]The calculation, however, is a statistical one, and does not relate availability of total production to the actual utilization of the crude. For example, extra production available in Alberta is of little significance in Montreal unless the pipeline facilities are available. The vulnerability of eastern Canada, now completely dependent on imports, is a key issue with United States energy negotiators.

[6]Shortages of low sulphur fuel oils on the United States Eastern Seaboard have stimulated exports of these products from refineries in Quebec and the Atlantic region.

4:25 The Canadian self-sufficiency on crude oil trade account is influenced largely by the National Oil Policy. These ground rules were set down in February 1961 and essentially held that markets west of the Ottawa Valley in Ontario should be served by Canadian oil, principally from Alberta and Saskatchewan. The balance of the country would use imported crude. By limiting the westward movement of imported oil, the National Oil Policy in effect ensured a certain minimum security of supply. The measure was necessary in the 1960s because of the differential between costs of imported and domestic crude, heavily in favour of the former. Without the National Oil Policy, imported crude could have captured the Ontario market.

Reserves

4:26 It is a popular fallacy that Canada has unlimited reserves of liquid hydrocarbons, principally crude petroleum. This unfortunately is not the case.[7] From the Leduc discovery in Alberta in 1947, reserves of crude oil in western Canada, principally in Alberta, increased steadily with some remarkable jumps as specific fields were discovered. The outlook now, however, is for remaining reserves in western Canada to peak in 1972 and thereafter decline from 10.2 billion barrels to 8.0 billion barrels by 1980. The great bulk of this volume will still be in Alberta where the decline is from 9.5 billion barrels in 1972, to an estimated 7.5 billion barrels by 1980. Compared to Alberta, the other Prairie provinces are of relatively minor significance. Saskatchewan reserves currently amount to some 670 million barrels with an additional 57 million barrels in Manitoba.

4:27 From a strategic viewpoint, the most appropriate way to regard reserve estimates is through their life index, that is, the number of years the reserves would last at current production rates. In Alberta, for example, the current life index is 21.3 years. This, however, will drop rapidly, reaching a level of just over 11 years by 1976.

4:28 In Saskatchewan, the decline is steady and at a much lower rate, the current level being 7.5 years and the estimate for 1980, 7.1 years. In Manitoba the life index is also at a low level, declining from 9.8 years in 1972 to an estimated 8.0 years in 1980.

4:29 Combining the three Prairie provinces, therefore, the composite life index for 1972 is 16.3 years, declining sharply to 11.3 years by 1976 and levelling off somewhat thereafter. Therefore, 1976 seems to be an important year in Canada's crude oil supply position.

Future Production

4:30 Crude oil production in Alberta currently is 1.4 million barrels per day, and this is expected to increase to 2.2 million. Production may level off at this rate and then begin a gradual decline to two million barrels per day by the end of the decade.

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[7]Conventional oil reserves only, excluding the Alberta tar sands and heavy oil reserves which rank among the largest in the world.

4:31 The Alberta decline would be much greater but for the increase in synthetic crude production expected by 1976. The second Athabasca tar sands plant, timed to come on stream in that year, will be appropriately phased to offset the decline in conventional crude oil production. Crude production from conventional sources is expected to reach a plateau of approximately two million barrels per day by 1976, but by 1980 may have declined to 1.7 million.

4:32 In Saskatchewan, the second-ranking oil producing province, output has already peaked at approximately 245 thousand barrels per day. From that level, production is expected to decline steadily to 182 thousand barrels per day by 1980. Manitoba, already fully extended on secondary recovery, is expected to hold a level of 15 thousand barrels per day, with nominal declines to 12 thousand by 1980. Finally, production in British Columbia has also peaked, and no significant improvement is expected beyond the current level of 75 thousand barrels per day.

4:33 Combining these principal conventional sources of supply, therefore, total available crude production in Canada is expected to increase from 1.9 million barrels per day in 1972 to a plateau of 2.5 million which should prevail between 1976 and 1978. By 1980, however, production should have dropped back to two million barrels per day.

4:34 The conclusions are clear. Canadian markets will require substantial volumes of production from frontier sources by the late 1970s, without reference to maintaining existing export markets or indeed contributing further to export market growth.

4:35 What then are the possibilities? The Alberta government will encourage additional tar sands development by expediting the application proceedings and possibly by royalty concessions. By 1975 synthetic production from the existing Great Canadian Oil Sands Ltd. plant could be doubled to 80 thousand barrels per day. By 1980 the new Syncrude plant could be on stream at 200 thousand and the GCOS unit at 100 thousand for a total of 300 thousand barrels per day. By 1985 another project could be in operation bringing the total to 450 thousand barrels per day.

Table 4:4

Forecast of Possible Canadian Crude Production to 1990

(Thousand barrels per day)

	Conventional	*Synthetic*	*Frontier*			*Total*
			Arctic Rim	*East Coast*	*Total*	
1970	1,382	40	—	—	—	1,422
1975	2,268	80	—	—	—	2,348
1980	1,947	300	500	100	600	2,847
1985	1,850	450	1,000	250	1,250	3,550
1990	1,750	600	1,500	500	2,000	4,350

4:36 Predicting frontier development is more difficult. In Athabasca, the extent of the oil reserves has been known since the turn of the century. On the frontier, however, threshold reserves must be proven before the necessary transportation facilities can be built. If the reserves are found and on the basis that all other requirements are met and the problems solved, the Mackenzie Delta may be in production by the late 1970s, adding 500 thousand barrels per day by 1980 and 1 million barrels per day by 1985.

4:37 On the East Coast – even more difficult to predict – exploration results to date have not been as encouraging, but the possibility of commercial production is there. It is assumed that this area will provide 100 thousand barrels per day by 1980 and 250 thousand barrels per day by 1985.

4:38 Combining declining conventional crude production with these additional sources, Canadian oil production could maintain growth over the next 15 years, approaching the three million barrels per day mark by the end of this decade and possibly reaching 3.6 million by 1985 and 4.4 million barrels per day by 1990.

NATURAL GAS

Production

4:39 Production of natural gas in Canada has increased by approximately 2.5 times every five years since 1950, from 67 million cubic feet in 1950 to 2.5 trillion cubic feet in 1970.

4:40 Alberta has maintained a dominant role in supply, surprisingly constant, moving from 86 per cent in 1950 to 84 per cent in 1970. In 1970, British Columbia production amounted to 13 per cent of the Canadian total, while the other producing provinces, Saskatchewan and Ontario, accounted for 2.5 per cent and 0.6 per cent, respectively.

4:41 The significance of this predominance of Alberta production lies in the dependence of most of Canada's natural gas markets on this one province for the bulk of supply. The pricing implications of this "one source of supply" are also significant. Ontario does import minor volumes of natural gas from the United States but not sufficient to exert any price pressure. In fact, the "exportable surplus" basis of exports to the United States, and the National Energy Board regulation of imports, both tend to reduce the United States price influence.

4:42 Producers, principally in Alberta, would like to receive the benefit of the full force of rising United States gas prices. Utilities in eastern Canada, on the other hand, seek some kind of buffer. This is the basis of the "two price" system whereunder export prices would be permitted to rise, while domestic consumers were given some degree of protection.

4:43 In 1960, domestic markets accounted for 75 per cent of total Canadian gas production, but sharply rising exports reduced the ratio to 54 per cent by 1970.

The outlook is for limited exportable surplus until a northern pipeline is operational. Sharp increases may be expected from time to time if additional exports are authorized, particularly with the completion of new pipelines which bring a "surge" of production to the market.

4:44 In 1960, industrial markets accounted for 37 per cent of total sales, followed by residential markets 25 per cent and commercial 12 per cent. Export markets accounted for 26 per cent of the total. By 1970, domestic markets had declined, industrial markets in Canada accounted for only 29 per cent, residential sales 15 per cent, and commerical sales 11 per cent. Exports now accounted for 46 per cent of total Canadian gas shipments – but still only 4 per cent of United States demand.

4:45 In 1970, Ontario was the largest single market for Alberta gas, accounting for 29 per cent of the total. Other markets of significance were the United States, east of Rockies 18 per cent, and west of Rockies 26 per cent. Alberta's own use accounted for 17 per cent.

Reserves

4:46 Canadian natural gas reserve life index has dropped sharply over the past decade as production has tripled, while new reserve additions have declined. The reserve index indicated 52 years of supply in 1960 but by 1971 this had dropped to 27 years. These estimates refer to the Western Canada sedimentary basin.

Table 4:5

Canadian Natural Gas Proven Reserves 1960 - 1970

(Trillion cubic feet)

	Year End Reserves	*Production*	*Years of Supply*
1960	30	0.58	52
1965	40	1.25	32
1970	53	1.80	29
1971 (est.)	54	2.00	27

4:47 Unofficial estimates of proven reserves at the end of 1972 suggest 15 trillion cubic feet for the Mackenzie Delta and 13 trillion cubic feet for the Arctic islands. Delta gas discoveries may already have reached the minimum volumé needed to support a pipeline. The threshold volume for the Arctic islands has been placed at between 25 and 30 trillion cubic feet and if the past discovery rate continues, the reserve threshold may be reached by the end of 1974. Therefore, it is possible that Delta gas will be available in the late 1970s, with Arctic islands gas availability following closely.

Future Gas Supply

4:48 Future gas supply for Ontario is protected by the National Energy Board limiting exports to those reserves surplus to Canadian requirements over a future period. The overall gas supply position is of interest, however, in relation to possible future price trends.

4:49 On the basis of production from conventional sources, i.e., the Western Canada sedimentary basin, exports to the United States will be restricted to modest increases, levelling off at one trillion cubic feet per year by the mid-1970s. Through the 1980s, the exportable surplus will drop rapidly unless the rate of finding gas in the Western Canada sedimentary basin increases sharply.

Table 4:6

Future Gas Supply and Disposition 1970 - 1990

(Trillion cubic feet)

Western Sedimentary Basin Only	*1970*	*1975*	*1980*	*1985*	*1990*
Production	1.8	2.7	2.5	2.5	2.1
Domestic Requirements	1.0	1.7	2.2	2.7	3.2
Available for Export	0.8	1.0	0.3	-0.2	-1.1
Including Frontier Areas	*1970*	*1975*	*1980*	*1985*	*1990*
Production	1.8	2.7	3.5	4.0	4.1
Domestic Requirements	1.0	1.7	2.2	2.7	3.2
Available for Export	0.8	1.0	1.3	1.3	0.9

4:50 Assuming a gas pipeline for the Mackenzie Delta by the late 1970s, this could add one trillion cubic feet per year to gas supply and 1.3 trillion cubic feet could be available for export by 1980 if approved.. Extension of this development of the addition of an East Coast offshore development could add another 0.5 trillion cubic feet by 1985 bringing total production to 4.0 trillion cubic feet, and holding exports at 1.3 trillion cubic feet. It is assumed here that increased availability of this magnitude would not influence prices (downward) and hence would not increase domestic demand.

COAL

Production

4:51 Coal is the most abundant fossil energy resource in Canada. However, about 93 per cent of Canada's coal reserves are located in Saskatchewan, Alberta and British Columbia, remote from the coal markets of Ontario which are more readily accessible to water-borne United States coal. As a result, two-thirds of total consumption is imported. Western Canadian coal, however, has recently established substantial exports to Japan and this has revitalized the industry in western Canada.

4:52 After 1945, the ascendancy of oil as a fuel caused substantial contractions and shifts in coal markets. Consumption of coal in Canada reached a peak of 47 million short tons in 1948, but had declined to 32 million short tons by 1970.

4:53 Domestic production in 1970 was 17 million tons with 5 million going to export. Imports, at the same time, amounted to 20 million tons. Future coal demand in Canada will depend largely on thermal generation requirements for electric utilities and coal for coking. Virtually all residential and commercial demand is expected to disappear by 1980, at which time domestic coal production could reach 60 million tons, with about half going to exports. By 1980, Canadian demand could be almost 50 million tons, with about 20 million tons coming from imports.

4:54 The utilization of coal beyond 1980 will be dependent on the availability of additional natural gas production, most likely from frontier areas. If this new gas does not become available by 1980, major coal gasification plants in Alberta are likely. This gas could reach Ontario through the TransCanada PipeLines.

Reserves

4:55 Coal reserves in western Canada amount to 118 billion short tons, approximately 93 per cent of the Canadian total. Saskatchewan has approximately 12 billion tons, Alberta 47 billion tons and British Columbia 59 billion tons. About 3 per cent of the reserves are located in Nova Scotia and the Yukon and Northwest Territories. Smaller deposits occur in New Brunswick and there is the Onakawana lignite deposit in northern Ontario south of James Bay.

4:56 Reserves of low and medium volatile bituminous coal in western Canada are estimated to be 86 billion tons, of which a small percentage is economically recoverable metallurgical grade coking coal. This would support annual production of 50 million tons over one hundred years. Improved mining and beneficiation techniques will probably increase the economically recoverable reserves, as well additional exploration. Of equal significance in increasing economically mineable reserves will be the steady upward drift of prices.

4:57 Reserves of thermal coals exceed 30 billion tons, including the highly volatile bituminous (non-coking) coals in British Columbia and the Alberta foothills, the Alberta sub-bituminous coals, and the Saskatchewan lignites.

4:58 It is evident, therefore, that Canadian coal resources are considerable and, consequently, the question of adequacy of supply does not arise. Ontario is currently dependent on United States resources and these, too, are considerable. Furthermore, the Ontario requirements are minimal in relation to United States resources.

4:59 Adequacy of supply is, however, affected by two geological factors which hamper the evaluation and production of Canada's coal resources.

(a) The vast deposits underlying the Prairie regions of Alberta and Saskatchewan (about 21 billion tons) are almost universally buried beneath thick glacial deposits. This factor affects the prospects for strip mining.

(b) The coal seams of the high rank coal deposits of the mountain coal fields, comprising the bulk (about 90 billion tons) of Canada's resources, are severely faulted and folded because of the geological uplift of the Rocky Mountains. These coal seams are frequently lying at steep inclinations and no economically accepted production techniques has yet been developed. Currently, the expanding industry is centred on the more easily extractable coal, particularly where surface mining can be employed or where underground operations can be started in moderately dipping coal beds. Thus, adequacy of coal supply will depend to a very large extent upon the development of suitable techniques for mining these steeply inclined seams.

Costs

4:60 Production costs at the Prairie strip mines of Saskatchewan and Alberta are among the world's lowest. Costs at the surface mines in the mountain coal fields also compare favourably with similar operations elsewhere.

4:61 Future prices for coal will depend on the economic factors of supply and demand,[8] including environmental and social costs at the point of production and consumption. At the mine, there have been problems of reclaiming land following strip mining operations and disposal of rock waste piles in an acceptable manner. At the point of consumption there is the atmospheric pollution problem. Existing techniques are effective for the partial capture of solid particulates, but there is not yet adequate control over the emission of gases, including sulphur and nitrogen compounds. The disposal of ash is an economic problem and there is insufficient data for designing stacks to cope with varying meteorological conditions. Solutions to these problems are of economic and social importance not only to the coal industry but also to ensure that the larg industrial consumers can continue to employ this abundant, relatively low cost fuel.

4:62 Market prices of coal are heavily dependent upon efficient, reasonably priced bulk transportation. Express coal trains were introduced in 1970 for the westward haul to Vancouver but similar facilities for moving western coal to Ontario do not yet appear to offer a competitive alternative to United States supply. The Canadian railroads are, however, working on the concept of unit trains which could make western coal competitive in Ontario within this decade.

THE ROLE OF FRONTIER RESOURCES

4:63 One of the most important elements in Canadian energy policy in the 1970s and beyond, will be the significant change in emphasis between provincially-controlled and federally-controlled resources. Frontier oil and gas reserves will emerge as the future cornerstone of Canadian energy production. If Alberta production of conventional oil and gas reaches maximum levels in the 1970s as pre-

[8] And on the supply of other energy sources.

dicted and begins to decline thereafter, the role of federally-controlled oil and gas reserves in the frontier areas will become increasingly significant.

4:64 Crude oil production in the province of Alberta, which has dominated Canadian supply since 1947, could under certain possibilities gradually fall into a secondary role.[9] The position of a prorated crude source alongside a rapidly expanding "concession type" area of production, presents many problems.

4:65 The rate of development of frontier oil and gas reserves will be influenced strongly by the availability of export markets – essentially in the United States. This is particularly so in the case of natural gas, where the "surge" market effect will be an important factor. This means that initial production through an economically scaled pipeline from the Arctic Rim (or the East Coast offshore area) will require an initial throughput greater than total Canadian demand, even by the mid-1970s. The normal market development pattern has been on an incremental basis, where new fields and pipeline extensions have added relatively minor volumes of supply.

4:66 A good comparison would be the Mackenzie Delta and the Athabasca tar sands. Production from the Delta will have to reach market in substantial volume in order to justify the pipeline. On the other hand, the development of the Athabasca tar sands will proceed on an incremental basis, adding units of approximately 150 thousand barrels per day at a time. This level of incremental supply addition will, by the mid-1970s, merely keep up with the normal growth of demand for Canadian crude oil: In other words, if Canadian supply growth were to be entirely dependent upon the tar sands by the late 1970s, one new plant per year would be required.

4:67 Another prominent feature of frontier resource development will be the increasing significance of transportation. Not only will there be substantially greater capital costs, but also the ratio of transportation to total costs will increase.[10] A further factor will be the increased role of the federal government in authorizing facilities.

4:68 The large initial capital requirements will mean that careful consideration will have to be given to the financial implications of the project. The sums of money involved approach $5 billion for an Artic Rim pipeline. The financial parameters involve the important question of ownership as well as balance of payments, and rate of exchange considerations on which policy decisions will have to be made.

4:69 A major factor when moving toward frontier development is the increasing emphasis on environmental protection. This has been foreseen, and considerable effort is being made by industry and the federal government to anticipate the many environmental problems. Not all these have yet been solved.

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[9]Initial crude production from the Mackenzie Delta would probably be 500 thousand barrels per day. This would represent about one-quarter of Alberta production. Delta production, however, would rise rapidly to one million barrels per day.

[10]The nature of frontier development implies large, prolific structures which tend to keep down unit finding and development costs. The related high production rates are necessary for initial pipeline throughputs.

4:70 Development and marketing of frontier oil and gas will introduce a new pricing element to Canadian and Ontario energy supply. The distance from markets and the high cost of exploration and development will account for most of the increase. A new influence on overall Canadian energy prices lies in store by the mid-1970s.[11] This frontier pricing basis will affect wellhead values of oil and gas in Alberta and Alberta wellhead prices will try to equate with the value of the frontier product passing the province. In other words, Alberta prices in the early 1970s may edge up in anticipation of the equivalent frontier commodity value in the late 1970s.

4:71 One aspect of the future development of frontier resources which is a major policy issue today, is the concept of reserve thresholds. Basically, the frontier companies, or consortia, maintain that the entire threshold of reserves must be protected until sufficient has been proven to justify the pipeline. For example, if the gas threshold for an Arctic line is estimated to be 25 trillion, and to date reserves proven amount to 15 trillion, this 15 trillion should not be included in the Canadian calculation of reserves, and so be available in the form of an exportable surplus.[12] These companies argue, and correctly, that if this 15 trillion is not earmarked specifically for the Arctic development, then it is conceivable that the threshold of reserves required would never actually be achieved.

4:72 Another reserve issue could emerge with the development of offshore natural gas reserves on the East Coast. These reserves presumably would be marketed in Montreal first, and eventually would replace Alberta gas in Ontario, freeing this product for other Canadian markets and for export to the United States under the present method of calculating the exportable surplus. The question arises whether or not the East Coast offshore gas should be dedicated to eastern Canadian markets or whether it should be included in the total Canadian calculation.

4:73 Ontario's best interest would be served by having two competing sources of supply, one from the West and one from the East, meeting in the Toronto area.[13] The extensive storage areas in the southwest of the province should be further developed to optimize use of these sources of supply. The development of frontier resources of oil and gas are essential for Ontario in the future because the outlook for supply from the conventional sources in Canada is limited. The questions are ones of timing and method.

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[11]The recently signed Imperial Oil contract puts a wellhead value of 32 cents per thousand cubic feet on Mackenzie Delta gas presumably available by 1976.

[12]If it were, and the 15 trillion cubic feet were contracted, conventional production sources in Alberta could not supply the product.

[13]It should not be expected that East Coast offshore gas will be "cheap" because it is nearer. It is likely to be priced to meet Alberta gas (or Arctic Rim gas) in Ontario.

Chapter 5

Environmental Protection and Energy in Ontario

INTRODUCTION

5:1 The availability and the cost of energy have long played a critically important role in the economic growth of modern societies. The expanding use of energy has become an outstanding factor in the achievement of rising standards of living and in the improvement of the quality of life through the removal of a vast amount of physical drudgery from daily work and through the provision of many comforts and conveniences in the home, in travel and in communication. In most of its forms, particularly in the form of electricity, the use of energy has been growing more rapidly than either population or total production. However, this highly dynamic aspect of material progress is being accompanied by consequences which have a rising potential for harm to human health and general well-being.

5:2 The rapid exponential growth in the production, transportation, conversion, and the use of energy involves large disturbances in the natural environment and large emission of wastes into the air and water. Increasingly, these disturbances and emissions have reached a scale in particular locations and circumstances which exceeds the capacity of natural processes to cope with them. Whenever this happens, valuable resources and amenities may be destroyed and the quality of life degraded. Consequently, policies and programs concerning the

development and use of energy must henceforth have adequate and timely regard for environmental considerations. Unlike the past, these considerations must in future occupy an appropriate place of priority in all planning and decision-making concerning energy, alongside convenience, availability and cost. Environmental issues must no longer be approached as an afterthought or as matters to be "cleaned up" after the event. They must be taken fully into account and dealt with from the very beginning.

5:3 The remainder of this chapter is devoted to a brief discussion of the environmental impact of the production, transportation, conversion and use of energy with particular reference to matters which will have significance for future policy in Ontario. Many complex environmental problems are associated with energy consumption and the chapter can only summarize them. A more complete and comprehensive discussion is contained in a report to the Advisory Committee on Energy by the Energy and the Environment Subcommittee, "Final Report, Impact of Energy Use on the Environment," November 1972.

ENVIRONMENTAL ISSUES ARISING FROM THE PRODUCTION OF PRIMARY ENERGY IN ONTARIO

5:4 Primary energy sources existing in Ontario are relatively small with the exception of uranium and hydro power. For many years, there has been a limited production of oil and gas in southern Ontario, and there are significant deposits of lignite coal in the Onakawana River area in the North. While the production of fossil fuels is not substantial in Ontario, it is in order to draw attention very briefly to the environmental consideration which must be provided for in developmental policies. Moreover, it should be recognized that increasing environmental concerns in other provinces and countries from which Ontario imports its fuel will give rise to new mining and drilling restrictions and higher fuel costs.

5:5 The production of oil and gas gives rise to environmental problems in the use of land and the possible pollution of water. Air pollution by oil and gas wells is minimal at present. Possibilities of oil spills are always a danger during drilling and production and they can have severe consequences, especially in under-water locations, such as Lake Erie. The search for oil and gas often takes place in unexplored or previously inaccessible areas. Methods used in finding oil deposits, the location of drilling sites, the development of roads and the disposal of wastes have environmental consequences, including those relating to the protection of forests, wildlife and fish.

5:6 There is at present no coal production in Ontario, but there is a probability that the Onakawana lignite deposits will be developed.

5:7 The mining of coal generally has important environmental impacts on land, water and air. The most far-reaching impact is on the land, especially in the case of strip mining. If serious long-term environmental damage is to be avoided, the land must be rehabilitated as a continual process so that the natural conditions are distrupted for as short a time as possible and the impact on animal and other life and natural processes is minimized.

5:8 Air pollution dust problems can occur in the mining or crushing operations. Run-off water from coal heaps or the coal deposit itself can be contaminated by the solids that might be carried along and by dissolved minerals which could substantially alter the acidity of the surrounding land and water. The particular problems of the Onakawana deposits in these respects should be manageable if proper safeguards are provided for at the outset.

5:9 The environmental impact of large-scale, hydro-electric power installations in northern areas is not well studied or understood. The northern environment is much more delicate than the southern and the tolerance of this environment to man's activities is not well understood. This is all the more serious because large dams and diversions have environmental implications which go far into the future. In Ontario, most of the few remaining unharnessed water-power sites are in the northern areas. In addition, hydro-electric plants are often used to supply peak loads. Even for a small plant this can result in rapid and large fluctuations in water level and a large impact on the aquatic environment.

5:10 The mining of uranium can have a significant impact on the environment over a large area and this has been recognized in Ontario through the regulations which have been applied to uranium mining in the province. This is the only fuel which Ontario exports in significant quantities and if these exports are increased substantially in the future, environmental effects could be considerable if suitable steps are not taken. The water pollution aspects of this mining are in general more serious than those for coal mining elsewhere in North America and in addition iron sulphides in the overburden and discarded wastes from some ore react with water to cause acid mine-drainage problems. Disposal of uranium mining wastes can increase significantly the radioactive and chemical contaminants in local streams and ground waters. Some concentartion of radioisotopes may occur through absorption by aquatic life.

5:11 The air pollution problems associated with uranium mining have not given rise to large increases of airborne radioactive substances. While the increase in levels does not appear to be a health hazard at present, this factor will need continued attention as output expands.

Table 5:1

Pollutant Waste Load for the Elliot Lake Region Corresponding to a Production of 4500 Tons of Uranium Oxide

	Type	*Yearly Average*
Ra-226	microcuries/day	4,300
Alpha Emitters	microcuries/day	39,000
Beta Emitters	microcuries/day	38,700
Dissolved Solids	lb/day	301,000
Total Nitrogen	lb/day	8,300
Sulphates	lb/day	171,000
Iron	lb/day	2,100
Chlorides	lb/day	8,500

Final Report, Energy and the Environment Subcommittee, *Impact of Energy Use on the Environment,* November 1972, p. 80.

5:12 Uranium mining, as in the case of the other kinds of mining, can have far-reaching effects on plant life, wildlife, and the landscape. The problem of desposing of radioactive wastes resulting from mining operations has long-range consequences. The present-day effects of releasing or concentrating radioactivity either in the soil or water are at present not believed to be serious, but the accumulative effects must be studied further and constantly monitored.

ENVIRONMENTAL ISSUES ARISING OUT OF THE TRANSPORTATION OF FUELS AND ENERGY IN ONTARIO

5:13 The transportation of fuels and the transmission of electricity from one location to another can give rise to important environmental problems in a number of respects. There is the general problem of land use for large-scale transportation and transmission facilities and there is the problem of accidents and breakage. As the volume of fuel movement increases, so does the risk of large and serious mishaps.

5:14 The spillage of oil, whether crude or processed, on land or water, can create large scale hazards and can damage local environments for long periods of time. Oil spillage into the water can contaminate local beaches and make them unsuitable for use for lengthy periods, kill surface plants and animal life, interfere with the transfer of oxygen and carbon dioxide from the top of the water thus affecting sub-surface plant and animal life. Methods of cleaning up and confining the effects of oil spills have progressed rapidly in the past few years. International contingency plans exist to handle these problems, but the effects of any oil spill nevertheless impose heavy social costs and can have far-reaching implications. Major breakages in an oil pipeline can have serious consequences including the contamination of ground waters. Natural gas pipelines involve a particular hazard because gas is extremely inflammable and under certain conditions highly explosive.

5:15 The main problem with coal handling has not been transportation, but storage. The necessity for large stockpiles (generally due to lake transport) can create coal dust problems which will raise the level of particulates in the immediate area at times. This problem is often solved by wetting down the stockpiles with water and by the use of binding agents. Water run-off from coal storage piles is normally collected and treated and is not a problem.

5:16 An increasingly important problem in transportation of fuels and the transmission of energy is the impact on the use of land. Firstly, there is the rapidly growing amount of land required for the many rights-of-way needed for rail, pipeline, and electric power transmission lines and their associated pumping or transformer stations. Secondly, there is the disturbing effect of several independent rights-of-way on sound land-use planning, on public amenities, and on aesthetics. Thirdly, the location of routes and of large-scale installations of various kinds can lower land values and can affect the distribution of population. Finally, the unregulated construction of rights-of-way combined with careless methods of land clearance and of prevention of unwanted vegetation can have important and lasting effects on the surrounding habitant of animal and plant life.

ENVIRONMENTAL ISSUES ARISING FROM THE CONVERSION OF FUELS INTO USEFUL ENERGY

5:17 The processes used in converting fossil fuels into useful energy have given rise to a large and rapidly increasing volume of pollutants which are emitted into the air and water. These emissions have, in the past, tended to be localized in densely populated areas. However, these problems have now become less localized as the facilities which cause them have increased in size and number. It is obvious that the rapid exponential growth in the production of energy can in future, more than in the past, result in a progressive degradation of the environment unless adequate and timely safeguards are instituted.

(a) **Generation of Electricity Using Fossil Fuels**

5:18 Fossil fuels are at present, and will be for some time to come a major means for the generation of electric power. Table 5:2 shows the weight of pollutants emitted into the air over Metropolitan Toronto from the use of fossil fuels from April 1971 to April 1972. The table indicates the large emissions from the generation of electric power, particularly with reference to sulphur dioxide and nitrogen oxide.

5:19 Excessive sulphur in our atmosphere can create serious health problems and damage to buildings and plant life. At present, technology does not exist for removing sulphur from coal by economically feasible means. Methods of removing sulphur from natural gas are now fully effective and practical. Presently, the most commonly used fossil fuels for electric power plants are coal and fuel oils which contain varying amounts of sulphur. One way of reducing the burden on the environment is to use fuels with low sulphur content or fuels that have had the sulphur removed at the refinery. However, these tend to be more expensive. Another way is to remove the sulphur from the stack gases, but the processes available today are costly and unproven for power plant application. Still another way of coping with this problem in the present state of technology is to limit the ground-level concentration of pollutants by the appropriate location of generating stations and by improving the diffusion of emissions into the atmosphere through the use of tall stacks.

5:20 It will be noted in Table 5:2 that electric power generating plants are large contributors of sulphur dioxide and nitrogen oxide emissions to the atmosphere. In addition, in Toronto the two power plants contributed about 13 per cent of the man-made particulate matter to the atmosphere. Particulates create a problem of aesthetics because of the soiling as the matter falls out of the atmosphere. They also cause in severe circumstances a health hazard to humans, particularly in cases of chronic lung and other respiratory diseases. The heavy metals which are emitted as a part of the particulate can have long-term consequences. The small amounts of radioactive materials also in the particulate matter add to the natural background doses of radioactivity we all receive. However, practical methods do exist for the significant reduction of many types of particulates and continued progress in this technology is being made.

Table 5:2

Emission Summary by Pollutant for Metropolitan Toronto

(Period April 1, 1971 to April 1, 1972)

Millions of Pounds Emitted Per Year   Percentage of Total Shown in Brackets

Source Type	SO_2	*Particulate*	NO_x	*CO*	*HC*
R. L. Hearn G. S.	34.64(7.33)	0.62(1.23)	26.44(13.14)	0.29(0.03)	0.12(0.06)
Lakeview G. S.	348.28(73.74)	5.94(11.82)	80.19(39.87)	2.00(0.23)	0.81(0.43)
Municipal Incinerators	0.55(0.11)	12.13(24.15)	1.35(0.67)	3.28(0.38)	0.16(0.08)
Industrial Sources	23.25(4.92)	12.08(24.05)	17.64(8.77)	4.89(0.57)	43.64(23.50)
Autos	3.49(0.73)	4.65(9.25)	43.65(21.70)	827.36(97.53)	126.42(68.09)
Railroads	0.43(0.09)	1.08(2.15)	2.19(1.08)	0.59(0.06)	1.33(0.71)
Shipping	0.90(0.19)	0.41(0.81)	0.66(0.32)	0.24(0.02)	0.32(0.17)
Aircraft	0.24(0.05)	1.18(2.34)	1.14(0.56)	2.21(0.26)	10.61(5.71)
Heating – Residential	19.82(4.19)	2.49(4.95)	5.91(2.93)	0.52(0.06)	0.76(0.40)
Heating – Apartments	10.73(2.27)	3.99(7.94)	5.68(2.82)	3.88(0.45)	0.84(0.45)
Heating – Schools & Univ.	8.29(1.75)	0.83(1.65)	2.69(1.33)	0.29(0.03)	0.11(0.05)
Heating – Publ. & Com. Bldgs.	14.40(3.04)	2.83(5.63)	10.77(5.35)	0.74(0.08)	0.34(0.18)
Small Industries	7.19(1.52)	0.83(1.65)	2.54(1.26)	0.23(0.02)	0.10(0.05)
Incineration: Apartments, Schools, Small Industrial, Publ. and Commercial Buildings	0.07(0.01)	1.16(2.30)	0.26(0.12)	1.76(0.20)	0.11(0.05)
Total	472.29	50.22	201.08	848.26	185.66

Final Report, Energy and the Environment Subcommittee, *Impact of Energy Use on the Environment*, November 1972, p. 59.

5:21 Nitrogen oxides constitute a potential health hazard. As is the case with most air pollutants, there is a small natural background level of nitrogen oxides in the atmosphere which results from natural processes in the nitrogen cycle. The added burden contributed by the combustion of fossil fuels can, under particular circumstances, result in the formation of photochemical smog. This form of air pollution may cause human discomfort and extensive vegetation damage. Because intensive sunshine and still-atmospheric conditions are needed to produce these special chemical reactions, photochemical smog is not common in Ontario. It has been learned that if sulphur dioxide is present in the air it tends to inhibit smog formation. Consequently, a complex situation can exist in which the reduction of sulphur dioxide emissions may increase the smog formation potential in a city and the decrease of nitrogen oxide emissions will decrease the potential for smog formation. Studies are being carried out to determine if and under what conditions smog may form here. Practical methods of removing nitrogen oxides from the stack gases of large users of fossil fuels are presently lacking while the methods for removal of sulphur dioxide are costly and at present not completely reliable.

5:22 Another problem which is common to all forms of electric power generation except hydro power is the discharge of thermal wastes. When fossil and nuclear fuels are converted into electrical energy, only a part of their energy content is turned into useful work; the remainder is emitted as waste heat. Fossil fuel plants have an efficiency in the neighbourhood of 35 per cent. That is, only 35 per cent or so of the heat produced is converted to electricity. Thes rest is lost in terms of useful work. Most of this heat is lost in the cooling of steam, and the cooling water is taken from and returned to our lakes and rivers. With systems presently in use, the possibilities of the useful employment of this waste heat are limited. There is much debate whether, and if so when, the problems of thermal wastes will become a serious matter in the Great Lakes aside from local effects near the discharge. The low water temperatures and high flow rates of the Great Lakes system are able to tolerate the present thermal waste load. It is the rapid exponential growth of needed electrical capacity which generates the long-range concern.

5:23 Once-through cooling is presently the most commonly used method of disposing of waste heat. This is the previously mentioned process by which great quantities of water are taken into the plant and discharged at temperatures up to 20 degrees Fahrenheit higher. The particular methods of employing once-through cooling are presently the subject of extensive research by Ontario Hydro. Disposal of this heat on the shoreline of lakes and rivers can have both beneficial and detrimental environmental effects depending on the local site conditions. There may be an enhancement of recreational use in some areas or a degradation of a suitable environment for water life in others. Hence, the siting of plants and local conditions must be carefully considered in the planning and design of a plant.

5:24 Other methods in use for disposing of waste heat also have environmental consequences. Cooling towers can create local weather problems arising from the emissions of great quantities of heat and water vapour to the atmosphere. All these

problems make it essential to exercise careful long-range planning in the location of large electric generating plants in the future.

(b) Generation of Electricity by Nuclear Power

5:25 Emissions of certain amounts of radioactivity from nuclear power plants is at present a normal occurrence. Many precise precautions have been taken to minimize the risk locally and globally. Standards have been set as to the total emission of great quantities of heat and water vapour to the atmosphere. All these ployees can be subjected to. What these limits should be is a continual source of debate among scientists. Many maintain that not enough is known about the long-term effects of radiation on human, plant and animal life, to make any significant increase in the background readings tolerable. The only certain answer is that if we are committed to nuclear power, then the limits should be set as low as is technologically practicable and not merely at a level which seems at present to be unharmful. Some believe that it is presently possible to reduce radioactive emissions to a fraction of what is currently allowable through relatively minor expenditure.

5:26 The possibility of accidents is probably the most critical environmental concern today regarding nuclear power plants. These accidents could range from relatively small internal releases of potentially lethal doses of radiation to a complete failure of some of the so-called "failsafe" systems, either by sheer accident or design (wars, sabotage, etc.). These systems depend in large part on the proper functioning of many mechanical devices and on key personnel doing exactly what they are appointed to do at the right time. Many of these systems have not been, and cannot be, tested under actual situations, so that they could fail when needed, even though the probability is very small. The Canadian CANDU system is reputed to be one of the safest systems in the world, but this should not eliminate concern. The need for close and continuous surveillance of these systems cannot be overstated.

5:27 A very important problem regarding nuclear power generation relates to the storage and disposal of waste radioactive products. Some of the products have half-lives of up to 25,000 years or more and may emit harmful radiation doses for up to a million years. This calls for a reliable system of protection against nuclear wastes which will be effective for at least ten times recorded history. The implications of this are very large. How can future generations be guaranteed against possible large-scale radioactive poisoning? Many proposals for the disposal of the ultimate wastes produced by nuclear fission have been put forward, but most are at best relatively short-term solutions (10-100 years). The assumption is that technology will have advanced by that time so that the wastes can be recovered or disposed of in a safer or more permanent manner. Scientists are anxiously devoting themselves to the problem, but as yet no solutions have been put forward that satisfy the critics. A satisfactory solution must be found before there is a massive commitment to nuclear power, at least to those types of nuclear power which yield the more dangerous wastes. Here also the Canadian CANDU system now being used by Ontario Hydro has important advantages over other systems.

5:28 Finally, consideration must be given to the disposal of waste heat from nuclear power generation. Nuclear power plants have at present lower thermal efficiency than fossil fuel plants, and consequently, the waste heat discarded into the water is significantly larger. The same environmental considerations arise as in the case of fossil fuel plants, only more so.

(c) **Generation of Electricity by Hydro Power**

5:29 While hydro-electric power generation is meeting a smaller and smaller proportion of Ontario's energy needs, it is becoming more important for providing the peaking load capacity of the system. This is in most circumstances the most environmentally damaging mode of operation for a hydro-electric plant. In the past, it has been both economically and environmentally sound to develop and harness our water resources. Recent experiences by other countries and other provinces have made the further development of hydro power look less environmentally attractive than was formerly the case. The implications of diverting large amounts of water to reservoirs which cover large areas of land are raising increasingly difficult issues relating to the environment, human habitation and plant and animal life. It is certain that these concerns will call for very careful study, research and evaluation before any major hydro project can be undertaken in the future.

ENVIRONMENTAL ISSUES ARISING FROM THE INDUSTRIAL PRODUCTION OF FUELS AND OTHER PRODUCTS

5:30 Oil and gas refineries have in the past been significant contributors to oil and water pollution. Waste water from these plants often carry oil and phenols. In their operations, they produce large quantities of sulphur oxides, hydrocarbon vapours, nitrogen oxides and particulates. These emissions can be expected to increase as the overall refining capacity increases although the emissions per barrel refined may actually decrease. Increased size and complexity of plants will also make refinery accidents and upsets potentially more dangerous. Upsets in chemical processes cannot be avoided entirely and consequently there is a continuing need to improve safeguards and to devise adequate methods of monitoring emissions and their impact on the environment. Removal of sulphur from many refinery products is now common. The cleaning of waste water is now also common practice but attention must also be paid to the removal of harmful dissolved materials which is more difficult. Refineries may be sources of malodorous compounds which must be controlled in order to avoid annoyance to the surrounding population. The problem of producing "clean" refineries which can consistently adhere to adequate air and water pollution standards will continue to require very close attention by the design and production engineers.

5:31 Coal is used in large quantities in the metallurgical industries, particularly in the iron and steel-making industry. The coal is used in the form of coke and the coke-making process has in the past created severe environmental problems, particularly in the pollution of air and water. The discharge of sulphur oxides and particulates into the air and of sulphides, phenols, ammonia and other compounds

into the water can cause both serious damage and widespread degradation of the landscape. A great deal has been done to reduce pollutant emissions from these sources but as the scale of metallurgical operations increases, larger problems are created which must be watched and dealth with promptly.

5:32 The production of energy in general industry usually takes two forms, the production of in-plant electricity and of in-plant steam. The production of electricity raises all the problems discussed previously regarding the production of electricity by fossil fuels, only on a smaller scale. The age of the particular plant has a large bearing on the volume of emissions and their consequences. There is generally less of a problem with heat disposal since the cooling water is often used for other plant processes. Air pollution problems arise in the case of plants which only produce steam for heating and process purposes. The actual effect is again often a function of the age and repair of the particular plant. However, the cumulative effect of many small plants can have serious consequences, especially when these plants are located in high-density population areas. The effective control of small energy production facilities is an important but often difficult matter.

5:33 The nuclear fuel industry includes both the processing of uranium ores to produce nuclear fuels and the processing of nuclear wastes for either storage or disposal purposes or the re-refining of new nuclear fuels. Here we are dealing with the problems of radioactive materials and radioactivity and the consequences of emissions and accidents on human health and safety. The dangers and considerations are similar to those which have been discussed in regard to nuclear power. There may be increasing economic pressures to reprocess nuclear fuel or provide enriched uranium fuel for export. The amount of radioactive emissions resulting from these processes are greater than those resulting from obtaining and utilizing nuclear fuel for the CANDU system. Great care must be employed before proceeding in this direction.

ENVIRONMENTAL ISSUES IN THE USE OF ENERGY

(a) Automotive Vehicles

5:34 Table 5:2 shows that transportation accounts for over half of the man-made pollutants emitted to the air in Metropolitan Toronto. It will be noted also that the automobile is by far the largest contributor in this category. Unlike other fossil fuel operations, the emission of sulphur dioxide by automobile is not significant because the lighter components of oil used in gasoline blends do not contain a high sulphur content. Carbon monoxide, nitrogen oxides, hydrocarbons and lead are the most significant pollutants emitted by automobiles into the air. Indeed, the automobile is the main man-made source of these pollutants in our atmosphere.

5:35 Carbon monoxide is a substance that at some concentrations is poisonous to living organisms especially animal life. The major source of carbon monoxide is from combustion processes and about 80 per cent of all of this comes from internal combustion engines. In high-density population areas with a high concentration of motor cars, the burden of carbon monoxide in the air can be an increasingly serious hazard to health.

5:36 Hydrocarbons along with nitrogen oxides are the ingredients for the production of photochemical smog. On a global scale man contributes only a small portion of the hydrocarbons normally present in the atmosphere. In large urban areas, however, where there is a high concentration of automobiles, man's activities have a pronounced effect. In some urban areas photochemical smog may result from a combination of factors, including the emission of hydro-carbons and nitrogen oxides, together with sunlight and certain climatic conditions. All of these conditions are not common in Ontario cities. However, these factors may combine to create health problems as well as personal discomfort in the form of eye irritation, and the situation must be carefully watched to foresee future problems.

5:37 Automobiles are the major contributors of lead in the atmosphere due to its widespread use as an anti-knock agent in gasolines. Lead is poisonous to humans and high concentrations, when these occur in the atmosphere in urban areas, may be harmful to health, although the present atmospheric lead levels are not generally believed to be a health hazard.

5:38 Public transit contributes on the average much less pollution per passenger mile than does the private automobile, as shown in Table 5:3.

Table 5:3

Efficiency of Various Means of Urban Transportation

Transportation Mode	*Btu used per passenger-mile*	
	Urban	*Intercity*
Walking	200	
Bicycle	300	
Bus	3700	1600
Railroad		2900
Automobile	8100	3400
Aeroplane		8400

Source: Dr. R. H. Hay, Advisory Committee on Energy.

5:39 The contrast between the private automobile and public transit becomes more significant when one considers that it is probably easier to develop public transportation systems that have less environmental impact than it will be to reduce the environmental impact of a vast number of automobiles.

5:40 In order to cope with the rapidly growing problems of air pollutants emitted from high concentration of vehicles, governments are applying increasingly tighter emission controls on the automobile. These controls raise costs significantly both because of the considerable cost of the devices that are necessary and because of higher fuel consumption. Because of these higher costs, there continues to be much controversy over the extent to which these controls are necessary. However, the controls can bring about a substantial reduction of automobile emissions, especially if stringent standards are applied as is shown in Table 5:4.

Table 5:4

Estimated Automotive Emissions in Ontario

Year	Total Emission									Vehicle[1] Population
	Carbon Monoxide[1] (1000 tons/yr.)		Hydrocarbons[1] (1000 tons/yr.)		Nitrogen Oxides[1] (1000 tons/yr.)		Lead[2] (1000 tons/yr.)		Sulphur Dioxide[3] (1000 tons/yr.)	
	No Controls	Controlled	No Controls	Controlled	No Controls	Controlled	No Controls	Controlled	No Controls	
1970	2,487	2,241	364	339	127	142	7.2	7.2	7.84	2,625,000
1974	2,968	2,185	434	312	152	167	8.8	8.8	9.60	3,133,000
1975	3,000	1,402	439	226	192	167	9.2	3.8	10.00	3,200,000
1980	3,700	874	541	125	237	89	11.4	0.9	12.40	3.900,000
1985	4,450	675	666	106	291	37	13.2	—	14.40	4,800,000
1990	5,600	717	819	122	358	29	17.2	—	18.70	5,900,000

[1] Estimated by J. G. Jefferies, Chief, Automotive Emissions Control Section, Air Management Branch, Ministry of the Environment.

[2] Based on estimated average lead content of gasoline sold in Ontario (2.6 g. lead/US gal.)

[3] Based on estimated average sulphur content of 0.4% for Ontario gasoline.

Final Report, Energy and the Environment Subcommittee, *Impact of Energy Use on the Environment*, November 1972, p. 199.

5:41 Transportation is probably one of the most serious social and aesthetic problems associated with land use. High concentrations of automobiles in large urban areas have resulted in the development of massive expressways which are exceedingly costly, use large amounts of land needed for housing and other purposes, departmentalize cities, increase congestion, and generally lower the quality of life in their immediate vicinity. The challenge of coping with these problems relates to more than the matter of good land-use planning — it involves many complex social and political issues. It involves the entire human environment in its largest sense.

(b) **Use of Energy and the Creation of Noise**

5:42 Community noise levels are becoming an ever-increasing concern of the public. Noise arises in a number of ways from the use of energy in transportation. Vehicle noise is to some degree associated with fuel consumption. A car without a muffler is much noisier but slightly more efficient and hence requires a little less fuel. On the other hand, a rapid acceleration is both much noisier and wasteful of fuel. In general, quieter vehicle operating procedures will probably result in fuel conservation. Greater human comfort near crowded highways or busy airports will involve both more rigorous regulatory standards and higher costs. The cumulative effect of traffic noise has been a subject of study by designers of highways in trying to lower the rising noise levels adjacent to major traffic arteries. To date, there have been very few solutions to this problem. One long-range alternative is to begin to reduce the noise levels of new vehicles.

(c) **Use of Energy for Residential-Commercial Purposes**

5:43 The main uses of energy in these fields are space heating, cooling and lighting. The use of electric apparatus by commerce and the use of electric appliances in homes are not major factors in the consumption of energy.

5:44 The major portion of the energy consumed in residential and commercial buildings is used for space heating. All but a relatively small fraction of this energy is produced by fossil fuels in small installations. As elsewhere, the burning of fossil fuels results in the emission of pollutants into the atmosphere. From Table 5:2 it will be seen that space heating contributes the following percentages of particular pollutants emitted into the air over Metropolitan Toronto: sulphur dioxide — 11 per cent, nitrogen oxides — 12 per cent, carbon monoxide — 1 per cent, hydrocarbons — 2 per cent, particulates — 20 per cent. The importance of these emissions is accentuated when it is considered that they are emitted very near ground level, and thus the direct effects on human health and welfare are much more immediate than in the case of large central stations with high stacks that dissipate their emissions over a very large area. The effects of small individual heating installations can thus be seen to have a significant effect on air quality. From the environmental standpoint, the emission of pollutants from home heating installations varies with the particular fossil fuel used and its quality. Natural gas is relatively "clean" and oil has advantages over coal.

5:45 The efficiencies of small home furnaces which are properly adjusted range from 60 to 80 per cent depending on the type of fuel used. When this is

compared to the 30 to 40 per cent efficiencies achieved in the production of electrical energy in central stations, it would appear that small individual furnaces provide the most efficient heat source for space heating and hence minimize the emission of pollutants. These considerations have given rise to arguments that the heating of homes and other buildings by electricity, which has been promoted by electrical utilities, is an unsound policy. It is argued that this results in increased consumption of scarce fossil fuels and consequently in an unnecessarily large emission of pollutants into the air. However, the advocates of electric space heating reply that the following factors must be taken into consideration: 1) Electrically heated buildings tend to have higher insulation standards than do non-electrically heated buildings, and thus use less heat; 2) Individual heating plants are almost never in the best possible adjustment and thus the rated efficiency and the actual efficiency differ widely; 3) Even if the furnace is properly adjusted, the rated efficiency reflects normal operating efficiency and often does not take into account start-up and shut-down periods when these units are operating far below their rated efficiency. No doubt, these factors tend to narrow the gap between electrical and non-electrical heat production efficiencies in the use of fossil fuels, but these factors may also be regarded as a listing of what improvements should be made on residential heating systems.

5:46 Another factor to be considered in this debate is the possibility of the control of atmospheric emissions and the enforcement of regulations. It is easier to deal with relatively few centralized heating plants than with millions of individual heating units. If the waste heat from electric generating plants could also be put to use for heating purposes, the difference in efficiencies could be further reduced. Nevertheless, the critics maintain that the deliberate promotion and the subsidization or marginal costing of electric home heating is wrong policy from the standpoint of the public interest, because of the greater use of scarce fossil fuels and because of the higher pollutant emissions, even though such promotion might be justified in the short run in certain circumstances by a particular utility. Clearly, large considerations of public policy are involved in this matter, and it is important that the means exist whereby the necessary information can be ascertained and decisions made in the public interest rather than on the basis of short-run gains.

5:47 Because so large a fraction of the total consumption of fossil fuel is devoted to use in residential and commercial buildings, mainly for space heating, it is a category of use where conservation could play a substantial role. There is considerable scope for more and better insulation in all buildings; for the development of innovative devices to achieve greater efficiencies and "cleaner" fuel use such as the heat pump, fuel cells, etc.; for better balance between heating and cooling; and for greater economy in lighting and the operation of appliances of all kinds. The application of conservation measures along these lines will undoubtedly be accelerated by the rising prices of energy in the years ahead. However, in future, measures for conservation of energy as well as our other resources must have a higher priority in our affairs for another important reason, namely, the protection of the environment.

Chapter 6

The Effects of Technology on Demand for and Supply of Energy

INTRODUCTION

6:1 Several promising technological developments for energy production, energy conversion or energy use are unlikely to have wide commercial application during our forecast period. Consequently, it is not meaningful to try to calculate their technical or economic potential at this time. It is possible, however, to estimate changes in demand which may be expected from improvement of technologies now in use, and from technologies nearing commercial application, or which are known but for various reasons not widely applied.

6:2 Among technological applications in which changes may be expected to affect demand for energy, are a) energy conversion devices, ranging from central electricity generating stations to domestic burners to automobile engines, and b) energy conservation techniques such as improved insulation, or district heating from a central source.

6:3 Supply will be affected by new production techniques which allow extraction of greater amounts of fossil fuels from given reserves, and by techniques which allow known resources such as the tar sands to be utilized.

6:4 Invention and innovation are related by the economics of production cost. Many technical processes are well known today which are not yet economically viable. However, as energy costs increase through the 1970s, some of these tech-

niques will become economic. For example, the technology of coal gasification is of little commercial significance when delivered gas prices are in the fifty cents per thousand cubic feet range, but may be attractive at one dollar per thousand cubic feet. For the next decade at least, rising energy prices will accelerate the commercial application of existing technology.

ENERGY DEMAND

6:5 Effects of technological changes on energy demand have been considered under the conventional energy market subdivisions: a) generation of electrical power; b) industrial; c) transportation; and d) residential-commercial.

Electric Power Generation

6:6 Hydro-electric stations in Ontario operate at 80 to 90 per cent efficiency or better, whereas, thermal-electric stations operate in the range of 30 to 40 per cent efficiency. The latter range is low because more than half the heat produced in the furnace gets lost in the condenser. This loss consists of the latent heat of vaporization which is given up to the circulating (condensing) water when the exhaust system is condensed.

6:7 Energy is extracted from water by allowing the water to fall through a range in elevation. Similarly, energy is obtained from steam by allowing it to fall through a range in temperature. In each case, energy remains in the medium after its discharge at the lower elevation or temperature. In each case, it is impossible to convert this residuum into useful electrical energy. Traditionally, this unused and unusable energy is charged against the efficiency of conversion in a thermal station but not in a hydro-electric station. The bottom end of the temperature range in thermal generation is fixed by the prevailing temperature of the condensing water. Therefore, the only way to improve on thermal efficiency is to increase the temperature of the input heat. It should be noted, however, that although the heated condensing water cannot be manipulated to improve the thermal efficiency of electrical generation, it could be used as a heat source for other purposes.

6:8 The history of fossil-fuelled thermal-electric power generation has been one of continually improving efficiency of energy conversion. Important factors have been the progressive increases in unit size, steam pressures, and temperatures; the use of single and double reheat; the increased efficiency of the feed-heating cycle, together with improved internal efficiency of equipment. For instance, the average coal-fired station heat rate in Ontario was 10,280 British thermal units per kilowatt hour in 1968, 8,850 Btu/kWh in 1969 and 9,620 Btu/kWh in 1970. The average station thermal efficiency increased from 33 per cent to over 35 per cent in a matter of three years. There is still room for improvement in Ontario. The best plant heat rate in North America is about 8,500 Btu/kWh for a 40 per cent overall efficiency. Beyond this, unit sizes reach a point where still larger units will add little efficiency. The sharply decreasing gain with more reheat gives little incentive to go to triple reheat, and the feed-heating cycle leaves small room for further improvement. Since internal efficiencies of the plant components are now quite high, any further gain will likely be in increments of one per cent or less.

6:9 Higher initial steam pressures and temperatures or development of acceptable binary cycles of combined steam-gas cycles are the likely sources of meaningful improvements in efficiencies of thermal-energy conversion. No serious work is presently being carried out in Ontario, or Canada, but new technologies are appearing in the United States which will permit system efficiencies as high as 45 per cent or better using a low-Btu gas in a gas-steam cycle.

6:10 Ontario Hydro's fossil-fuelled thermal-electric plants use superheated steam turbines, whereas the use of nuclear energy as a heat source has meant a return to saturated (wet) steam because of the relatively low outlet temperature of the reactor coolant. The outlet temperature of Pickering Nuclear Generating Station is around 572 degrees Fahrenheit and the thermal efficiency of the plant is about 30 per cent.

6:11 Current emphasis in nuclear power development in Canada is on efficiency improvement. The most important single attribute of the organic-cooled CANDU reactor as a variation of the heavy water-cooled CANDU system, is its scope for further development. Technology has been proved for organic coolants operating at a mean reactor outlet temperature of 752 degrees Fahrenheit. More recent work at the Whiteshell Nuclear Research Establishment on coolant decomposition and make-up indicates that outlet temperatures of the order of 842 degrees Fahrenheit may be considered. To put these numbers into context, it is highly probable that current technology will produce a practical net station efficiency between 35 per cent and 36 per cent. Future development could result in efficiencies of the order of 40 per cent. This would be achieved without the need of liquid metal coolants or fast reactors.

6:12 The use of organic (a hydrocarbon oil) coolant allows the transport of heat at higher temperatures and lower pressures than in water-cooled systems. It allows the consideration of materials and fuels that are unacceptable in high-temperature water systems. Together, these promise increased efficiency and lower capital cost. Also, the primary system is easy to maintain because there is little transport of radioactive corrosion products and because corrosion-induced maintenance is essentially eliminated. However, recently the A.E.C.L. have decided not to proceed with the development of this type of reactor for the time being.

6:13 Another central station energy conversion system which offers some promise over the long run is magnetohydrodynamics (MHD). With MHD, power is obtained from movement of a hot, electrically conducting fluid through a magnetic field. With open-cycle MHD, the conducting fluid is obtained from combustion of a fossil fuel and the hot combustion gases are "seeded" with potassium or cesium to increase conductivity and are exhausted to the atmosphere. With closed cycle MHD, the conducting fluid is continuously recirculated in a closed loop and is heated either by a fossil fuel or by an atomic reactor.

6:14 Magnetohydrodynamics promises high energy conversion efficiencies — as high as 55 per cent. However, a very large amount of developmental work must still be done before MHD can be considered commercially feasible, and it must be ruled out for use in Ontario during the forecast period to 1990. In the very long

run, perhaps its most promising application in Ontario would be in conjunction with advanced types of nuclear reactors.

6:15 It must be concluded that already-known technologies will continue to be used in Ontario's electric power generation sector over the next two decades, and that significant improvement in efficiencies can be expected in the nuclear power component particularly. Despite increasing lead times for new construction resulting in delayed feedback of operating experience on advanced designs and sizes, there will be notable and hard-earned advances in general. Such advancs in steam turbines may be expected by way of better materials and closer definition of material limits, increased understanding of the aerodynamics of the steam path and greater knowledge of steam forces on rotors. Similarly, advances in generation may include improved designs for extremely high electromagnetic forces in generators, improved generator insulating and cooling systems, including the possibility of superconducting rotors, and advanced control systems. Increasing environmental pressures to limit waste heat, economic pressures to conserve increasingly costly clean fuels, and the continuing growth of electric power, are all incentives to further advances in basic cycle efficiency levels.

The Industrial Sector

6:16 Energy input to the industrial sector (primarily the manufacturing sector) presents a very complex picture because of the great diversity of applications. Industrial energy requirements include: a) electrical energy for lighting and motive power; b) space heating; and c) energy for a very wide variety of specific industrial applications such as process steam production and metallurgical furnaces. Five industry groups accounted for about 70 per cent of total 1970 consumption of energy by Ontario's manufacturing industries. These were: food and beverage; paper and allied products; primary metals; non-metallic minerals and chemicals and chemical produucts.

6:17 The industrial demand for specific types of energy is changing rapidly. The use of gas is growing at a fast pace while oil is maintaining its market share, coal is declining significantly and the relative use of electricity is increasing moderately. Overall, energy demand by industry is growing steadily and is expected to continue to account for about one-third of total energy consumption in Ontario throughout the present decade. No major technological changes affecting energy use by industry are anticipated even though such changes may be made relatively quickly in certain types of light industry such as the food industry. Particularly in the primary metals and the pulp and paper industries, major innovations not now implemented are unlikely to affect substantially the demand for energy in the next ten years. For example, fifteen to twenty years may be necessary for new processes to be commercially applied throughout the steel industry.[1]

6:18 One particular area of technology which warrants specific mention is the recycling of post-consumer waste materials. The energy "costs" shown below

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[1]Source: Gold, B., Pierce, N.S., and Rosegger, G., *Diffusion of Major Technical Innovations in U.S. Iron and Steel Manufacturing.*

for both new and recycled industrial materials are based on United States studies and data but the "cost relationship" should be relevant to Canadian industry.

6:19 Recycling waste materials and support by the public through giving preference to products made from post-consumer waste can substantially reduce the volume of solid wastes and conserve both energy and the basic resource materials.

Table 6:1

The Energy Cost of Some Everyday Materials

		From Ore	*From Recycled Material*
Amount of energy, measured in pounds of coal, needed to make one pound of:	Steel	1.11 lb	.22 lb
	Aluminum	6.09	.17-.26
	Copper	1.98	.11
	Glass	.36	.36
	Cement	.33	—

Source: *Fortune,* October 1972, p. 110.

The Transportation Sector

6:20 The transportation sector accounted for about 17 per cent of total energy consumption in Ontario in 1970. It is expected that transportation will continue to account for roughly the same percentage over the next 15 to 20 years. Fuel consumption by motor vehicles in turn accounts for about four-fifths of energy expended in transportation.

6:21 It is unlikely that the internal combustion engine will be replaced on a broad scale in the near future. Possible alternatives to the internal combustion engine now in the experimental stage, require a great deal of further development. Assessment of changes in energy consumption through technological development must therefore first take account of newly instituted anti-pollution regulations for the internal combustion engine.

6:22 Attempts to comply with automotive exhaust emission regulations laid down by the United States Government to be effective in 1976 and regulations to be proposed by the Canadian Government, involve work on exhaust reactors, exhaust gas recirculation, engine modifications, improved carburetion and improved ignition. It is felt by some automotive industry observers that the stringent regulations may lead to a doubling of engine costs. It is expected that by 1976 emission controls will increase automotive gasoline consumption (i.e. gallons per mile) by up to 15 per cent above present levels. Non-leaded gasoline will be mandatory. However, such reductions in efficiency may be offset to some degree by a trend toward smaller automobiles and engines.

6:23 Other propulsion systems currently under development (although not displacing the internal combustion engine within the critical periods leading to introduction of rigid environmental protection standards) may well come into

widespread use within the next 10 to 15 years. These include gas turbines, external combustion engines, electric cars, improved urban transportation systems and improved long-distance freight and passenger movement systems.

6:24 Development work on gas turbines is being carried out by the major North American automobile manufacturers. However, general use of gas turbines in automobiles is believed to be a decade away at least. Their introduction would cause a gradual shift in automotive fuel consumption from high octane gasoline to less expensive fuels.

6:25 External combustion engines, in which fuel is burned in an open flame in a continuous process, are at present too costly, bulky and weighty to compete with the internal combustion engine except in large vehicles. Fuel consumption of the gas turbine and external combustion engine is of the same order as the fuel consumption of the internal combustion engine modified for emission control. The external combustion engine, of course, can utilize a broad range of petroleum fuels.

6:26 Development of the storage capacity of batteries has not reached a point which would give the electric car long-range operational capability. Although attempts are being made to develop a battery which would permit a range of at least two hundred miles, it is generally accepted that it will be many years before technology will have provided an all-electric substitute for the North American family car at a competitive price. The most logical introduction would be for the second or downtown car, leaving highway travel for the conventional first car.

The Residential-Commercial Sector

6:27 In 1970, approximately 28 per cent of total energy consumption in Ontario was accounted for by the residential and commercial sector. Of the sector total, about three-quarters was required for space heating. The remainder was consumed mainly in electrical and gas appliances. Energy demand for air conditioning was negligible (of the order of one per cent).

6:28 For space heating, oil consumption has grown steadily but gas consumption has grown most rapidly. Electrical resistance heating is presently of the order of one per cent of total fuel use in the sector and coal consumption is small and declining rapidly.

6:29 Obviously, application of technology to space heating problems offers the greatest scope for affecting energy use in the residential-commercial sector. Energy saving possibilities include improving the efficiency of conventional home furnaces; reducing heat losses from convection, conduction and infiltration; and introducing more efficient heat production, extraction and storage devices (e.g. heat pumps, total energy systems, heat recovery systems).

6:30 Recent developments such as flame-retainer heads and ultrasonic atomization have increased the maximum efficiency of the oil furnace so that it is now comparable to the gas furnace, both achieving about 90 per cent under steady running conditions. However, frequent on-off operation, poor adjustment and poor

maintenance tend to reduce the overall efficiency of oil and gas furnaces. It has been estimated that year-round efficiencies are 55 per cent for oil, and 65 per cent for gas furnaces.

6:31 It has also been estimated that if year-round efficiency could be increased to 75 per cent, and applied to all furnace units in the province, then overall fuel requirements could be reduced by about 15 per cent. On the assumption that most older furnace units could not readily be made more efficient, it is more reasonable to calculate the effect of an overall efficiency increase of 5 per cent. A saving of 5 per cent by 1980 would mean a fuel saving of about 27 trillion British thermal units, equivalent to 27 billion cubic feet of gas or 4.5 million barrels of oil.

6:32 When electrical energy is used for space heating and water heating, the system efficiency will be about 35 per cent if the electricity comes from a thermal station burning coal, oil or gas. Thirty-five per cent is the average efficiency of thermal electric power stations. However, this does not take account of the superior insulation or the more efficient and more flexible room heat control associated with electricity.

6:33 A new well-insulated home equipped with a modern gas or oil furnace will require less fuel than a similar home electrically heated from a thermal power station. In the past, however, hydro-electric stations have generated the electricity with no fuel consumption and in 1971 water power provided more than fifty per cent of the electricity generated in Ontario. In the past, therefore, electric space heating has not been responsible for a net increase in the consumption of fuel in the province.

6:34 In future, if better insulation is used in all house construction, and taking into account that thermal electric stations will provide a growing share of the electricity produced, electric space heating will be less efficient than the alternatives. Two further points should be noted however. First, it is not hydrocarbons that will be consumed in the thermal electric stations but uranium which is not in short supply. Second, should it prove possible to utilize the waste heat from the thermal station, the system efficiency would equal that for oil and natural gas in a house furnace.

6:35 Heat losses from buildings include heat transfer through walls, windows and ceilings by a combination of convection and conduction, and infiltration (the flow of cold ventilating air into a building). Heat transfer through walls is strongly affected by insulation; viz. increasing the thickness of conventional insulation material in a typical studded wall from half an inch to six inches will decrease the heat transfer rate by 60 per cent. Roughly the same reduction applies to ceilings.

6:36 Heat transfer through windows is much higher per unit area than that through walls. For a small bungalow it is estimated that the heat transfer through 130 square feet of single pane window would be at least half as much as the heat transfer through 2,000 square feet of walls with three-inch insulation. Use of double glazing or storm windows could cut window heat transfer roughly in half.

6:37 Energy required for heating ventilating air can be substantial. A ventilation rate corresponding to one air change every two hours — the recommended minimum air change rate — accounts for about one-third of the total heat load. Additional air infiltration through badly fitting doors and windows can greatly increase this proportion, and may represent as much as 70 per cent of the total heat load.

6:38 For the average new dwelling unit it is possible to cut heat losses by up to 10 per cent. This would encompass a combination of savings from increased wall and ceiling insulation depths, installation of storm windows or triple panes, improved weather-stripping, caulking, and addition of storm doors to cut down the rate of infiltration of outside air.

6:39 If it is assumed that higher construction standards were to be applied to new residential structures across the province to effect a 10 per cent saving in fuel costs, then the aggregate savings from 60 thousand new units built annually would be about six trillion British thermal units per year, or about 6 billion cubic feet of gas or 1 million barrels of oil in 1980.

6:40 Balanced against fuel savings would be added costs, mainly the cost of buying and installing additional insulation material. This cost, for a one thousand square foot bungalow, would be about $200 for increasing depth from an assumed two and one-half inches to four inches. The extra one and one-half inches of insulation would reduce the annual fuel bill by $24 to $36. This saving may not provide sufficient economic incentive to encourage better insulation. However, the aggregate saving of scarce fuel resources over the years would justify building to a higher standard than that currently prevailing.

6:41 A variety of energy conversion and storage technologies for the residential-commercial sector, some applicable to groups of buildings instead of single structures, are in an advanced stage of development but are not in general use. These include heat pumps, heat storage devices, total energy systems and district heating.

6:42 The *heat pump* is basically an electric air-handling system that cools a house in summer and heats it in winter by reversing its internal operation; effectively, it is an air conditioner that can be adjusted to work in reverse. Also the heat pump may be used in large buildings in which there is a core requiring cooling (due to lighting and human body heat) and perimeter areas requiring heating during the winter (due to heat loss to the atmosphere). In such buildings, the heat pump can be used to transfer energy from the core to the perimeter, thereby cooling the former and heating the latter. In this respect it is a form of a heat recovery system. When cooling is required in the building, all the heat can be rejected to the atmosphere.

6:43 The energy utilization of the heat pump system is good. However, it compares favourably with oil and gas systems only when the comparative costs of the latter systems include electric air conditioners. In areas with marked extremes of temperature, the heat pump system must be supplemented by electric resistance heating.

6:44 The heat pump is a common system in the mid-southern states of the United States where cooling and heating can be equally justified. It is not commonly used in Ontario but commercial package units are available. The heat pump has potential but its future role will depend on further development.

6:45 The possibility of *solar heating* for residential purposes has long been discussed. However, because solar energy supply is variable, and peak supply never coincides with peak demand in the heating season, it would be necessary to couple solar heating with an energy storage device — an expensive combination. Cost studies have shown that solar home heating is not competitive with oil and gas in the United States, except for one study location in California, although it does have an advantage over electric heating in some areas. It is generally concluded that solar heating cannot be expected to be an important factor in the United States for many years. The same conclusion can be drawn for Ontario.

6:46 Energy storage devices are used in various parts of the world (e.g. concrete block home heaters in the United Kingdom which utilize low-rate, off-peak electricity). Again, they are not considered to be particularly applicable to Ontario because they do not effect a net saving of energy use, and our electric power demand structure is not suited to thermal storage in off-peak periods.

6:47 Total energy systems have the capacity to supply both electricity and space heating and hot water requirements from one energy source. The total energy system consists of an electric generator powered either by a gas turbine or a reciprocating engine. Heat is recovered from the exhaust gases and may be used for space heating, or by absorption refrigeration, for cooling.

6:48 Several hundred total energy systems are in use in North America mainly supplying single complexes such as housing developments or schools. The feasibility of a total energy system in a given context depends upon several criteria:

a) Operation at fairly constant demand levels over long periods of time, in order to attain high operating efficiency and low unit cost;

b) a favourable ratio between demand for electricity and demand for heating or cooling, in order to assure use of waste heat; and

c) gas or liquid fuel prices which show an economic advantage over prevailing electricity rates.

6:49 These criteria have been satisfied in the numerous installations in the United States, due to a good balance between winter heating and summer cooling loads. This constraint would limit the widespread applicability of total energy systems in Ontario. However, a sharp increase in the price of electricity relative to fossil fuels could change the economic feasibility of total energy systems.

6:50 Fuel cells appear to offer long-term prospects for reduction of residential-commercial fuel requirements. The fuel cell, consisting basically of an anode and a cathode with a conducting electrolyte between them, can operate on natural gas or a variety of other hydrocarbon fuels. Because its efficiency is not limited by small size, and because it can also operate efficiently at part-load, it can be

used in single houses. With natural gas powering a fuel cell, all the energy needs of a household can be met. The gas can be used for space and water heating, and to feed the fuel cell which produces electricity. In addition to an operating efficiency in the vicinity of 50 per cent, the fuel cell promises high reliability and low maintenance costs, clean exhaust and adaptability. It is still in an early stage of development, but data from experimental installations indicate that the capital cost of a fuel cell system may be sufficiently low (roughly $200 per kilowatt) to make it economically attractive. A long development program is under way and widespread application is not expected in this decade.

6:51 District heating is a system of providing steam for heating groups of buildings or sections of towns or cities from a central heating station. It is widely used in the United States and Europe and is not uncommon in Ontario. A unit in downtown Toronto produces steam for distribution to several large commercial buildings. Similarly, a hospital steam station supplies steam to several large hospitals in the area. Many university campuses and other institutional and industrial complexes have a system of central district heating.

6:52 Advantages of district heating include economies of scale and the possibility of combining thermal generation of electricity with heat supply through steam or hot water. District heating offers greater opportunity for pollution control and lower unit costs for fuel supplies.

6:53 One of the factors holding back development of district heating in Ontario is that local utility companies are primarily concerned with electricity supply and have little interest in supplying heat energy. However, concern with pollution may provide impetus for modest development in major cities. District heating combined with central station total energy production could markedly increase fuel utilization efficiency.

ENERGY SUPPLY

6:54 Technological developments can affect energy supply through opening new areas for exploration and development, through improvement of extraction techniques, through improvement of transmission, and by enabling new kinds of fuels to be developed from previously unutilized resources.

6:55 Ontario's indigenous resources, limited except for uranium, may be increased to a small extent through: a) advancing gasification techniques which can use Onakawana lignite; and b) improvements in long-distance hydro transmission techniques. However, the importance of uranium far overshadows these other resources.

6:56 Technological developments are under way which will expand energy resources in western Canada – which currently supplies a significant part of Ontario's total energy needs – and in northern Canada, a potential source of supply for Ontario. Of greatest interest are the developments of the Athabasca tar sands and the oil and gas reserves in the Mackenzie Delta and the Artic islands.

6:57 Technological advancement is affecting energy resources around the world, particularly in respect to oil and gas. Offshore drilling capabilities are permitting the opening of large new areas to exploration. New techniques for shipping liquefied natural gas are creating a world market for natural gas. Although these developments may have no direct and measurable effect on Ontario's energy supplies, they are, nonetheless, of long-run significance to the provincial consumer by widening the sphere of supply and price influence.

6:58 Looking forward two decades, technology may open up entirely new supplies of energy. However, neither breeder reactors nor nuclear fusion can be viewed as serious possibilities within this period.

6:59 Existing technology can be used to expand Ontario's uranium reserves. The present reserves were discovered in two intensive periods of exploration. The probability of additional low-cost reserves being discoverd with further intensive exploration is very good. Also improvements in methods of refining uranium ores should reduce the cost of processing lower-grade ores and increase the availability of economic grades.

6:60 Ontario's undeveloped hydro-electric sites are remote from power consumption areas. Development of these sites is dependent upon use of the power near the site, or upon improved methods of long-distance transmission. Further advances in technology such as high voltage DC transmission may be anticipated, and could result in a number of sites in the northern part of the province becoming economic. It is likely, however, that sites which could be added to the power generation system in future will make only a marginal contribution to total provincial energy supply.

6:61 Ontario's coal resources are limited to an estimated 170 million tons of lignite at Onakawana, but indications point to larger unproven reserves. Coal gasification techniques are advancing rapidly, and may offer an alternative if development of the Onakawana deposit is considered.

6:62 Oil and gas from Alberta and Saskatchewan supply the great bulk of energy imported into Ontario. Although improved recovery techniques will marginally expand production from conventional western Canadian sources, the major long-run supplies are likely to come from the Arctic Rim and the Athabasca tar sands.

6:63 The technology of drilling under adverse conditions has advanced sufficiently within the past decade to allow exploration in the permafrost and muskeg conditions of the Arctic, as well as the offshore areas of eastern Canada. Alberta's Athabasca tar sands are estimated to contain some 250 to 300 billion barrels of recoverable synthetic crude oil. Great Canadian Oil Sands Ltd. has developed a recovery process of commercial scale and is currently producing 45 thousand barrels per day. Syncrude Canada Ltd., established by several major United States and Canadian-based oil companies, plans to install facilities to produce 125 thousand barrels per day by 1976. Both of these operations use surface mining techniques. However, about 80 per cent of the tar sands are recoverable only

by means of *in situ* combustion techniques, which are not yet economical. It is expected that technological advances permitting economic recovery will be made within the decade.

6:64 Offshore drilling technology is advancing rapidly, and it is now possible to drill in depths of several thousand feet. It is likely also that drilling in areas subject to moving ice conditions will shortly be possible. This would open up additional large areas of offshore eastern Canada to exploration.

6:65 New technological developments in coal gasification may eventually lead to Saskatchewan lignite and Alberta and British Columbia bituminous coals being used to supply pipeline gas to eastern Canada. Developments in the technology of transporting other fuels may work to enhance Ontario's supply position. Among such developments is the unit-train concept now being utilized to move fuel oil from Montreal to Kincardine. Unit trains from Quebec City will also supply the Lennox generating station near Kingston. This concept could also move Alberta coal to Ontario. The development of a coal/oil slurry pipeline is also possible, again moving energy from Alberta to Ontario.

6:66 Ontario imports the great bulk of its coal supplies from the northeastern United States. More efficient mining techniques will continue marginally to expand supplies from this source. Offsetting this will be increased environmental problems of land restoration at the mine sites.

6:67 Some six hundred cubic feet of gaseous natural gas can be stored or shipped as one cubic foot of liquefied natural gas (LNG). It liquefies at –259 degrees Fahrenheit. It can be transported by truck and tanker in special "thermos" storage tanks. Liquefied natural gas is being transported from North Africa to Europe, from Alaska to Japan, and current projects will involve shipments from Algeria and the Caribbean to the east coast of the United States.

6:68 However, liquefied natural gas facilities are usually capital intensive and, consequently, require long-term assurance of supply. Liquefied natural gas's future role in Ontario is expected to be relatively small and limited to off-season storage for peak-shaving purposes.

6:69 Among possible new sources of energy, nuclear fusion has now entered the experimental stage. Controlled nuclear fusion, with heavy water (deuterium) fuel, would represent sufficient energy to equal a million times the known possible fuel reserves of the world. The nuclear fusion reaction must be initiated by extremely high temperature. Several experiments have reached the requisite temperature but none has been held at that temperature sufficiently long to demonstrate the technical feasibility of initiating and controlling the fusion reaction. It is not expected that controlled nuclear fusion will be available until the early part of the next century.

6:70 The ultimate energy source is solar energy. Experiments are under way in many countries to utilize the heat from the sun. Problems of capture and storage are immense and the economic applicability of solar energy is also decades away for Ontario where climatic factors add further to the problem.

6:71 Hydrogen gas, as a secondary fuel, may have an important and complementary role in replacing fossil fuels. Not only can hydrogen be produced directly from fossil fuels and by the electrolysis of water, but there are prospects for conversion cycles using nuclear heat directly to decompose water at relatively moderate temperatures. Hydrogen is transportable as a pipeline gas or as a liquid. It can be stored under ground as a gas or above ground as a liquid. Hydrogen can then be distributed as needed for use as a direct heating fuel, as a raw material for various chemical processes, or as a source of energy for the local generation of electricity. When hydrogen is burned as a fuel, the only combustion product is water which is easily assimilated by the environment. Hydrogen may have particular relevance as a future fuel for Ontario because of the prospective dominance of nuclear energy in this province.

Chapter 7

Petrochemicals
A Non-Energy Hydrocarbon Sector

7:1 While hydrocarbons are regarded primarily as energy sources, they play a significant role as a raw material, specifically for the petrochemical industry. Any forecast or projection of the energy outlook has unavoidable implications for the petrochemical sector.

7:2 The non-energy applications of fossil fuels have expanded rapidly in the last twenty-five years. Usually we do not associate a wide array of everyday products — convenience items and many which are essential — with petroleum and natural gas. Plastics, fertilizers, insecticides, pharmaceuticals, synthetic rubber, man-made fibre textiles, explosives, carbon black, ammonia and a host of other products usced by modern societies are derived from petroleum or natural gas.

7:3 Feedstocks are vital to the petrochemical industry and there are no known alternatives to hydrocarbons as petrochemical feedstocks. Between four and six per cent of the total petroleum and natural gas consumption is used as raw material by the petrochemical industry.

7:4 The manufacture of petrochemicals began with the use of refinery propylene to make isopropyl alcohol during the 1930s. During the Second World War, the need to augment natural rubber supplies led to the development of

synthetic rubber which was produced by Polymer Corporation at Sarnia. In the main, however, the petrochemical industry is a product of the past quarter century.

7:5 The chemical industry in Ontario (i.e., all types of chemicals not only petrochemicals) spent $54 million on energy products in 1970. Approximately half was for electric power principally in the Niagara Falls area. Most of the remainder was for natural gas and petroleum derivatives principally in the Sarnia area.

Table 7:1

Ontario Chemical Industry Fuel Purchases 1970

	Percentage of Total	*Chemical as Percentage all Manufacturing*
	%	%
Solid Fuels	6.3	9.9
Petroleum Derivatives	13.5	8.5
Natural Gas	29.5	16.3
Electricity	50.7	14.8
Total	100.0	13.4

7:6 The Canadian petrochemical industry has the choice of two basic feedstocks – natural gas liquids or crude oil distillates. In Alberta, methane, propane and butane from natural gas streams have formed the basis for petrochemical development, while at Montreal the off-gases from the petroleum refineries provide the feedstock for petrochemical plants.

7:7 At Sarnia both sources of feedstock are used, liquefied petroleum gases and natural gas from Alberta as well as refinery gases. Demand for petrochemical feedstocks in Canada is about 40 thousand barrels per day and approximately half of this is for production in Ontario, principally at Sarnia. In addition, close to 25 billion cubic feet of natural gas is consumed annually in Ontario – primarily for the production of ammonia, again at Sarnia.

7:8 The petrochemical industry continues to grow at a rate well above most other industries – Canada and worldwide, petrochemicals have been averaging a 10 per cent per annum growth rate over the past several years. This substantially exceeds the rate of growth for energy and accordingly an increasing share of oil and gas production is required as feedstock. Concern is already beginning to be expressed about the long-term availability of raw material supplies in a world facing regional energy shortages. Future physical availability (as well as price) is a major concern.

7:9 The worldwide petrochemical industry is extremely competitive and producers in Canada have been under increasing pressure from foreign suppliers. The industry is experiencing a time of uncertainty and employment has been dclining. Seven per cent of world petrochemical investment is located in Canada.

However, in 1971, only four per cent of total world new investment was under way in Canada. Excluding ammonia, sales of Canadian-made petrochemicals reached $480 million in 1971. About $120 million were exported but imports totalled $300 million. Total Canadian demand therefore is estimated at $660 million in 1971.

THE FEEDSTOCK SUPPLY PROBLEM

7:10 In 1971, about 25 billion cubic feet of natural gas (methane) was used by the petrochemical industry as feedstock. This represented about ten per cent of all industrial gas sold in the province and six per cent of total gas demand. Approximately half of this requirement was located at Sarnia. Just under ten million barrels of petroleum derivatives (non-methane), about five per cent of total oil consumption, were also used as feedstock.

7:11 The petrochemical complex in Sarnia obtains its non-methane feedstock principally from the refineries in the area. Taking into account the market potential for the industry, these sources may not be adequate in spite of expansion of refining capacity in the province.

7:12 The change in motor gasoline by the late 1970s will influence the choice of feedstocks in petrochemical operations. Until now, natural gas liquids have made up 88 per cent of the feedstocks for ethylene with refinery naphta as the logical alternative. If, however, lead is no longer used in motor fuels, the refiners may divert some naphtha to motor fuel and accordingly the refining and petrochemical industries would be competitors for the same hydrocarbon supply. This trend in the United States with its much greater volumes, could be a major factor in setting costs of feedstocks through the decade.

7:13 Naphtha and other refinery products will be used in increasing quantities as substitute natural gas (SNG) for "peak-shaving" purposes by the natural gas companies. The petrochemical companies will be in direct competition with the energy industry for the available supply. For example, the amount of naphtha available in the world is insufficient to satisfy the needs for the substitute natural gas plants which have been proposed in the United States alone. The proposed substitute natural gas plants would require 640 thousand barrels per day which could make 3.25 billion cubic feet per day of substitute gas. This is almost equal to total world use of naphtha in petrochemical production.

7:14 Thus, the energy industries will supplement regular sources in order to meet increasing consumer demand. The effects of technology on motor fuels will alter the refinery mix. Both of these trends may place increasing supply pressure on the petrochemical industry.

7:15 Technology and changing energy demand has also tended to alter the energy product, sometimes to the detriment of the petrochemical producer. Concern has been expressed to the Advisory Committee on Energy that natural gas supplied as feedstock material has deteriorated in quality, particularly with regard to the sulphur content. The extra costs of dealing with this situation, it is claimed, have worked a hardship on the consuming companies.

7:16 More serious, however, is the concern expressed regarding the chemical content of the natural gas stream which moves from western Canada. Because natural gas liquids are extracted in western Canada, it may be necessary to inject butane or propane back into the stream in eastern Canada in order to maintain the Btu content of the natural gas. This substitution complicates the production of ammonia which uses natural gas as the feedstock material. Thus, changes in gas composition may have adverse effects on companies which rely on natural gas as a petrochemical feedstock.

FUTURE FEEDSTOCK REQUIREMENTS

7:17 By 1980, feedstock requirements can be very large if the industry is able to retain the Canadian market, and export to the United States. These conditions would be necessary in order to make construction of a world-size plant economically feasible. Competitive feedstock prices will be an important factor. Under these or similar conditions, the 1980 requirements in Ontario could reach 21 million barrels per year. Somewhat more than half of this would be required for a world-size ethylene plant fed on naphtha and producing a billion pounds per year. If ethane were the starting material instead of naphtha, the volume of feedstock would be 20 per cent less. Because of special requirements by certain customers in the Sarnia area, the use of naphtha as a base is favoured.

Table 7:2

Non-methane Feedstock Requirements 1980

Products	*Requirements*
Ethylene, propylene, butadiene plus possible gasoline and other fuel products	12 million barrels of naphtha *or* 9.5 million barrels of ethane
Ethylene, propylene, etc. from Esso plant	4 million barrels off-gases and other refinery streams
Benzene, toluene, xylenes	3 million barrels extracted reformate
Carbon black	2 million barrels heavy oils

7:18 The requirements of the petrochemical industry must receive special attention for several reasons. The industry is already large and well established in Ontario and with some accommodation can become an important element in the future economic growth of the province. If capacity growth in Ontario or other provinces is not adequate, the rapidly growing consumer demand for products of the petrochemical industry will be met by imports. With limited Canadian production, this industry's deficit in the Canadian balance of payments could reach or exceed $1 billion in little more than a decade.

Table 7:3

Petrochemical Feedstock Requirements in Ontario, 1971

	Product	*Estimated Feedstock Requirements*
Methane		
Canadian Industries Ltd. Sarnia	ammonia	12 billion cubic feet
Cyanamid of Canada Niagara Falls	ammonia	8 billion cubic feet
Brockville Chemicals Maitland	ammonia	3 billion cubic feet
Cornwall Chemicals Cornwall	carbon disulfide	500 million cubic feet
Dow Chemical Sarnia	chlorinated solvents	120 million cubic feet
Non-methane		
Esso Chemicals Sarnia	ethylene, propylene, butylenes, butadiene	4 million barrels off-gases and gas oil
Esso Chemicals Sarnia	benzene, toluene, mixed xylenes	1 million barrels extracted reformate
Dow Chemical Sarnia	ethylene, propylene	2 million barrels butanes
Shell Canada Sarnia	aromatics	600,000 barrels extracted reformate
Cabot Carbon Sarnia	carbon black	700,000 barrels heavy oil
Cities Service Hamilton	carbon black	425,000 barrels heavy oil (imported)
Texaco Canada Port Credit	aromatics	500,000 barrels extracted reformate
BP Canada Trafalgar	propylene	200,000 barrels off-gases
Celanese Canada Cornwall	methanol	100,000 barrels naphtha

FEEDSTOCK PRICES

7:19 Feedstock usually constitutes the major variable cost in petrochemical manufacture. As a result, production costs are particularly sensitive to feedstock price changes often brought about by shifts in the energy market. This sensitivity will be of increasing importance in the next few years as energy costs are expected to increase steadily. Further, many chemical processes require large quantities of heat so that in addition to raw material, input fuel consumption can represent as much as 10 to 15 per cent of the total hydrocarbon usage.

Table 7:4

The Relationship of Energy and Energy-related Raw Material Costs to the Total Manufactured Cost of Selected Products

	(Percentage) %		*(Percentage)* %
Ammonia	75	Carbon Tetrachloride & Perchloroethylene	51
Chlorine	50	Vinyl Chloride	57
Caustic Soda	40	Styrene	76
Ethylene Glycol & Anti-Freeze	48	Polystyrene	38
		Polyethylene	35

Source: Dow Chemical of Canada Limited. *Submission to National Energy Board,* 1971

7:20 Representation made to the Advisory Committee on Energy has pointed up the competitive price disadvantages and the future uncertainties in the purchase of hydrocarbon energy in Ontario when contrasted with other locations.

7:21 Ontario feedstock prices are substantially above those prevailing in many parts of the world and transportation charges from western Canada account for only part of the difference. Those petrochemical companies having access to feedstock supplies which are based on petroleum from the Organization of Petroleum Exporting Countries or from the Texas Gulf Coast area enjoy prices which are below those paid by Ontario industry.

7:22 Large investments have been made in Sarnia on the basis of long-term contracts for the supply of natural gas feedstock but these contracts are now in danger of being upset by price increases originating at the wellhead and augmented by increasing transportation costs. More specifically, in some instances the viability of new projects has been based upon normal price escalation of natural gas. Energy costs are facing upward pressures on a world-wide front. As a result of these influences world energy price differentials are expected to diminish but this trend may not work quickly enough to help the petrochemical industry. Various alternatives are being explored, including the concept of a "chemical refinery" in which the full production of the refinery is directed toward petrochemical feedstocks. Feedstock costs and scale of production are the two principal problems of the industry in Canada.

7:23 The ten chemical companies in Sarnia have good market location when compared with Montreal or Edmonton. The Montreal-based industry, however, benefits from the lower-priced imported oil while the Edmonton industry is able to draw upon the local natural gas raw material supply.

MARKETS

7:24 The potential demand for petrochemicals manufactured in Ontario is governed by consumption trends in Canada, the share of the domestic market Ontario producers can reasonably be expected to secure, and the possible business available given greater access to foreign markets. The controlling factor in the demand for petrochemicals is the growth in consumption of the major end-products. There will always be some sales of the "building-block" chemicals and intermediates in the export market for further upgrading but the greatest volume is normally converted to derivatives for sale in the home market.

7:25 The sheer diversity of petrochemicals precludes the manufacture of all products in Canada. An estimate of the total market, therefore, does not in itself establish the probable range of production in this country or in this province. An additional consideration has to be the extent to which other sources supply that market.

7:26 Even without a detailed look at specific markets, it is possible to obtain a rough measure of overall domestic demand. The industry seems in agreement that the present dollar value of petrochemical consumption (excluding intra-industry transfers) was about $660 million in 1971. It is expected that petrochemical usage in developed countries will continue to increase between eight and ten per cent per annum into the foreseeable future. Accordingly, the Canadian market should at least double during the decade, and treble by the mid-1980s.

Chapter 8

Future Energy Costs in Ontario

INTRODUCTION

8:1 Energy costs[1] as a percentage of gross national product declined from 11.5 per cent in 1950 to 8.9 per cent in 1970. This is surprising in view of the steady move to more expensive fuels (i.e., coal to oil and gas), but is largely explained by the relative decline in average fuel prices (in relation to other commodities), and improved technology and conversion. The consumer paid $1.54 per million Btu in 1950 compared with $1.39 per million Btu in 1970 for a much higher quality mix of energy. This reflects stable energy prices against a background of steadily increasing commodity prices.

Table 8:1

Canadian Energy Costs 1950 and 1970

	1950	*1970*
Gross National Product (Billions $)	18.2	84.5
Energy costs (Billions $)	2.1	7.5
Energy costs as percentage of GNP	11.5	8.9
Costs per million Btu (1970 constant dollars)	1.54	1.39

[1] Based upon average prices paid by the final consumer in energy transactions in all market sectors. Does not include taxes or other forms of transfer payments – see W. E. Barratt, *The Impact of Higher Energy Prices*, Alberta Economic Society, March 1972.

8:2 One of the consequences of the energy price stability over the last two decades has been the lack of opportunity to test demand price elasticities.[2] But it is evident that demand increased substantially in the face of steady prices.

8:3 In the United States and Canada, there had been a long-term decline in the relationship between total energy demand and real GNP. But in 1966 this trend was reversed and since then the amount of energy per unit of GNP has increased. It is impossible to say how much of this demand increase would have been postponed if energy prices had increased.

8:4 An important element in energy price/demand relationships is the fact that consumers primarily do not buy energy *per se*; they buy energy-consuming goods; only rarely is the cost of the energy which the unit will consume the decisive factor. For example, in buying a house or an appliance, the prospective fuel bills are not usually a primary consideration. Energy costs could be a factor in the decision of car buying. In all cases, the cost of fuel is relatively small in relation to other costs of upkeep and service, and it rarely affects the decision to use or not to use the article.

8:5 Even in the case of the automobile – the most energy intensive item of personal purchase – the average annual cost of gasoline is about 40 per cent of total out-of-pocket ownership costs. If capital costs are included, the gasoline share drops to 21 per cent. If the refinery cost of gasoline were to double (i.e., ignoring taxes and dealer margins) these ratios would increase to 50 per cent and 29 per cent, respectively. Any permanent pattern change in car use because of normal gasoline price increases would be modest. The same conclusions will apply to electric appliance use in the face of higher power costs.

8:6 Energy consumption – or more specifically the empirical basis of price elasticity of demand for energy – comprises millions of individual consumption decisions in the home, on the highways, at play, etc. But energy costs *per se* do not materially influence these decisions. If we assume, therefore, that total energy consumption is the aggregate of specific discrete uses in thousands of individual social systems, then we may further postulate that *purchases* of energy consuming items, such as appliances and cars, are more likely to be affected by energy prices than is their current energy *consumption.* As a result, energy price changes have a lagged effect on energy demand, if any at all.

8:7 How will pricing decisions be made as energy costs rise? For example, utility companies pool rates when these new costs are rising. A gas utility may receive "new" gas at a price several times its existing average gas cost. A situation where marginal costs are several times average costs will present new problems to utilities who, in the past, have encouraged marginal use at less than average prices.

8:8 This problem is presently at hand in the United States in the case of costly liquefied natural gas imports on the East Coast. The Federal Power Commission originally ruled that these high-cost marginal supplies cannot be

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[2] A conclusion shown by Foster Economic Consultants in their report *Prospective Prices for Energy Consumed in Ontario 1972-1985* prepared for the Advisory Committee on Energy.

"rolled in" to existing volumes and the added cost spread over the full range of consumers. However, this position has been changing. This will have the effect of limiting growth of demand by substantially increasing prices to new customers, especially for industrial loads.

8:9 Energy prices in Ontario are largely influenced by factors external to the province. The extent of this external influence can be demonstrated.

Table 8:2
Ontario Energy Sources of Supply - 1970

Energy Form		*Share of Total Supply*	*Regulatory Influences*
Petroleum	Alberta	18%	Alberta Energy Resources Conservation Board National Energy Board
	Saskatchewan-Manitoba	11%	National Energy Board
	Offshore	9%	National Energy Board
Sub-total		38%	
Natural Gas	Alberta	18%	Alberta Energy Resources Conservation Board National Energy Board Ontario Energy Board
Hydro & Nuclear	Ontario	19%	Atomic Energy Control Board
Coal	United States	21%	
Other	Various	4%	Miscellaneous
Total		100%	

8:10 The largest single supply sector is United States coal, followed by Alberta gas and oil. Alberta supplies 36 per cent of Ontario energy requirements. Over 80 per cent of Ontario's energy needs are imported from outside the borders of the province. The National Energy Board has jurisdiction over oil and gas movements while the provincial boards in Alberta and Ontario have powers over natural gas.

ELASTICITY OF DEMAND

8:11 It is assumed here that *total* demand for energy is relatively insensitive to incremental price changes – up or down – in the short term. The longer term relationship is not as predictable. It is also assumed that industrial demand is the most sensitive to energy cost changes and residential demand the least sensitive. Also, incremental demand (i.e., new customers) is more sensitive to price changes than existing demand.

8:12 The inelasticity of residential and commercial demand centres around certain characteristics of oil and gas and, to a lesser degree, of electrical power. Natural gas seems to be the premium fuel, and fuel oil has to establish a significant price advantage to compete, if gas is available. New housing developments generally install gas space heating with a furnace cost saving approaching $200 per house. Inadequate supply or the unavailability[3] of gas opens the market to oil or electric power.

8:13 In the industrial sector, fuel competition comprises heavy fuel oil, natural gas and coal. Some large industrial customers have the installed flexibility of using either oil or gas as price or availability dictate (as in the case of interruptible gas). This is the basis of the greatly increased price elasticity in the industrial market. However, long-term contracts can limit this flexibility.

ELASTICITY OF SUPPLY

8:14 Energy experts are far from unanimous in their views on the question of just how responsive is supply of energy (oil, gas or coal) to various kinds of price changes.

8:15 Lengthy time lags are a major deterrent to any direct supply/price relationship. Increased exploration today might not add to gas supply for three or four years, by which time many other market factors have changed. The availability of new geological prospects to develop will diminish over time, again reducing the price/supply response. New environmental constraints on the acceptability of various fuels also influence supply beyond the pure price effect.

8:16 In the past two decades, oil and gas prices were remarkably stable yet supply increased steadily both in Canada and the United States. Just how much more supply would have been made available if prices had been rising, is not clear. If in fact exploration activity had been encouraged above actual levels, production would not necessarily have been greater (being a function of demand) but remaining proven reserves might well have been greater. That is the crux of the United States (and to a lesser degree Canadian) problem today. Looking ahead, most authorities agree that substantially higher energy prices will be needed to significantly increase future availability of oil, gas and goal. The rate of return on incremental exploration outlays in traditional areas is diminishing. In frontier and offshore areas production economics are substantially different.

8:17 Environmental controls will make coal mining more expensive in future, as will labour safety codes. Both add to the price increase necessary to increase supply. Wellhead regulation of inter state gas in the United States has been blamed for that country's gas supply shortage. These restraints are being removed in part and there is now speculation as to what the supply effect will be. Restriction of outer continental shelf drilling is now the major United States supply constraint. Delays due to environmental concerns are holding up supplies from Alaska.

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[3] In some areas in the United States, e.g., Philadelphia, even new residential customers are being refused. Rejection of new industrial accounts is now widespread.

8:18 While substantially higher energy prices will no doubt encourage new exploration activity, there is no simple or inevitable correlation between these higher prices and increased future supply. This fact is of significance to Ontario where higher prices may be proposed on grounds of (among other reasons) security of supply.

FUTURE MARKET FACTORS

8:19 Energy price trends will be influenced by a number of particular circumstances. Most of these changes will be on the supply side with the structure of overall demand changing much more gradually. The most important single element is of course the United States gas shortage which in turn places greater responsibility on the petroleum sector. This applies in both Canada and the United States with differing regional emphasis.

8:20 In the United States, this shift to oil will greatly increase dependence on imports of crude oil and its products. This fact could be the most important single price influence in the seventies and beyond. The greatly enhanced bargaining power of OPEC[4] will provide a steady upward pressure on oil prices. The finding and development costs of new oil and gas will be higher and so will the selling prices. The recent 32 cents per thousand cubic feet contract for Mackenzie Delta gas is an example. This translates to approximately $1.00 per thousand cubic feet at Chicago. Frontier resources will be expensive to find, develop and transport. By the mid-seventies their price influence in major Canadian and United States markets will be well established.

8:21 Coal supply costs will be increased by environmental and safety code factors. Successful coal gasification applications by the late seventies will increase demand and add to price pressures. Environmental factors of coal consumption requiring the removal of particulates and SO_2 will also add tot he real cost of the fuel and thus tend to limit increased consumption to large industrial users.

8:22 Nuclear power, which is discussed in detail in Chapter 11, is a bright star on the energy horizon, especially in Ontario. Increased nuclear capacity will gradually reduce dependence on fossil fuels for thermal generation, freeing supply for industrial use.

PETROLEUM PRICES

8:23 Ontario oil product prices are influenced by OPEC, United States and Canadian crude oil prices. OPEC prices are expected to increase by 75 cents per barrel (over the 1971 level) by 1975, with further increases probable beyond that date. This would effectively close the present gap between OPEC and North American prices, assuming that changes in the latter will be of a lower magnitude.

8:24 United States crude oil prices have been protected by the Mandatory Oil Import Program since 1959, and United States oil has been priced about $1.00 per barrel over Middle East oil. This price spread is now disappearing.

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[4] Organization of Petroleum Exporting Countries

Cost pressures on domestic United States crudes are mounting, and when supplies from the North Slope of Alaska are developed, a new frontier cost element will be added.

8:25 If as predicted the United States is dependent on imports for approximately one-half of its oil by the mid-1980s, United States oil costs will be influenced to an increasing degree by tanker rates. The United States at present has only three ports (all on the West Coast) which can handle large supertankers. Using smaller vessels could add significantly to the total United States cost. United States crude oil prices will continue to narrow the gap in prices between the United States and the Middle East, eliminating it completely by 1980. Canadian crude oil prices will reflect these influences as well as other indigenous factors.

8:26 Development of frontier oil will introduce a new cost element whether from the Arctic Rim or East Coast offshore. While these new sources will not set prices, they will influence prices upwards.

NATURAL GAS PRICES

8:27 The pricing of natural gas differs from crude oil in that it is subject to regulation. Both in Canada and the United States various degrees and levels of regulation influence gas prices. In the United States the 1954 Supreme Court – Phillips decision enabled the Federal Power Commission to effectively freeze the wellhead price of natural gas moving in interstate commerce. In addition, the FPC and state regulatory bodies control the rate of return of pipeline and distribution companies, and this in turn forms the basis of the rate structures.

8:28 In Canada the Alberta Energy Resources Conservation Board decides what volumes of gas can leave the province – essentially the supply for the rest of Canada. The National Energy Board grants permission to move gas across provincial boundaries and, of greatest importance, the Board controls exports. The calculation of the exportable surplus is one of the most important gas-pricing influences in Canada.

8:29 Other elements of price influence follow. For example, long-term contracts for a substantial portion of supply limit the sensitivity of prices. These contract periods have tended to shorten and are now approaching five years. Also price renegotiation provisions are being increased as well as the rate of annual escalation. This escalation was originally one-quarter of a cent per thousand cubic feet per annum but new contracts may incorporate a higher minimum.

8:30 Behind these elements of regulation and contract comes the traditional market effect of supply and demand. Constraints on supply, coupled with universally strong demand factors, have built up strong upward price pressures.

8:31 On the demand side, the clean-burning virtues of gas, long merely a sales pitch, have become the symbol of environmental controls. As the other fuels such as coal and heavy fuel oil were criticized for their pollution effects, natural gas won more and more plaudits as the ideal fuel. Therefore, apart from

the steady increase in demand for gas as a fuel *per se*, there has been a compounding of demand on the basis of its combustion characteristics. While regulation and controls have limited supply, strong demand factors have been building up.

8:32 Little mention is made of producers' costs in these discussions of price. Cost are normally regarded as company information and details are not generally available. Production costs will vary widely between fields and between producers within any one field although all receive the same wellhead price. In other words, there is economic rent involved which will increase if the wellhead price of existing gas is increased. This introduces the question of equity between substantially increased economic rents for producers and comparably increased prices for consumers.

8:33 New gas reserves will cost more to find and develop, but newly developed reserves form a small part of the total gas supply in any one year. It is the already established gas reserves which will benefit most from future price increases through renegotiation clauses in the delivery contracts.

8:34 The removal of sulphur is a gas cost factor which deserves special mention: specifically with reference to the gas located in the foothills region of Alberta. Here, substantial reserves of "sour" gas have been proven but these are not economically viable because the cost of sulphur removal exceeds the value of the sulphur — generally in the five dollars per ton range. In this case a price increase of 5 cents to 10 cents per thousand cubic feet might be necessary to encourage development.

8:35 The finding costs of frontier gas are substantially higher and presumably development and production costs will also be higher than in the western sedimentary basin. It is probable that the great bulk of Canada's (and North America's) gas potential lies in frontier areas, including offshore. What then will be the price effect of frontier gas on production from the western sedimentary basin?

8:36 Frontier gas will be marketed in a surge approaching one trillion cubic feet per year in the early stages of development. This is roughly equivalent to total Canadian requirements at the present time. A volume of this magnitude will clearly need sizable additional outlets if it is to be brought to southern markets within the next several years. Apart from the national energy policy implications, this situation introduces a major United States pricing influence to the development of Canada's frontier gas. This has already been demonstrated in the initial sales contracts for Mackenzie Delta gas for United States markets. Frontier gas will not be delivered before 1976 so the prices referred to apply to markets still some four or five years away. But the contracted prices for 1976 delivery will have a very real bearing on current gas contract renegotiations. Prices in the intervening years may edge up to anticipate future relationships by the time frontier gas comes on stream.

8:37 This then is the background against which future gas prices must be gauged. Of one thing there is no doubt. Gas prices will go up. By how much and the extent of the regulation involved remains to be seen. However, there

seems to be a general consensus in industry, and in government, that wellhead price regulation is not desirable. Nevertheless government policies and controls regarding inter-provincial movements and exports will have strong influences on prices in Canada. To a considerable extent prices in Canada will depend on how these policies are exercised.

COAL PRICES

8:38 Yet another set of price influences are found in the case of coal. Being almost entirely an industrial fuel, including thermal power generation, coal is usually subject to long-term contracts which tend to restrict the price influence of current market factors. Ontario Hydro accounts for almost half of Ontario coal demand, and industrial (primarily metallurgical use) another 47 per cent, leaving only a nominal short-term market.

8:39 But despite long-term contracts, actual consumption of coal has been restricted by increasingly stringent air pollution controls especially in the United States. This has shifted demand to lower sulphur content coals and accelerated research in stack emission control systems – both of which will increase the cost of burning coal.

8:40 Coal production has a high labour content ranging up to 50 per cent of the selling price in Canada and the United States. Hence, coal prices are more inflation sensitive, since they are subject to contract price escalation provisions. The 1969 Mine Health and Safety Act in the United States added about 50 cents per ton to coal costs as well as restricting development of some mines and shutting down others. Costs of restoring and maintaining the environment at the mine have also added to product costs and will continue to do so. Coal is therefore unique as a fossil energy source in that both production and consumption involve substantial environmental costs. The development of commercial coal gasification, whether on-site or at market, will compound these problems by the late 1970s.

8:41 Most of Ontario's coal imports come from West Virginia and Pennsylvania. Prices from these sources were fairly stable through most of the 1960s but rose sharply in 1970 and 1971, roughly doubling from 22 cents per million to 39 cents per million Btu. This cost is expected to increase steadily through the present decade. Beyond, into the 1980s, coal gasification and improved air pollution control techniques will maintain the demand for coal but at a slower pace.

TRANSPORTATION COSTS

8:42 While the wellhead price of oil and gas is an important element of delivered cost, pipeline costs are also significant. Indeed, the largest single factor in the delivered cost of gas to Ontario distributors has been cost of transportation. Economies of scale tend to keep down unit transportation costs, but extensive expansion programs at sustained high interest rates keep a steady upward pressure

on costs of service. These comments apply to the major transmission lines as well as to the distributing utilities in Ontario. Nevertheless increased wellhead prices will account for the bulk of the consumer price increase.

8:43 Delivered crude oil prices in Ontario from western Canada are less sensitive to pipeline costs because of the lower pipeline component, 14 per cent of delivered cost versus 61 per cent in the case of natural gas. Economies of scale will be possible with crude oil transmission lines but it is difficult to estimate just how effective these might be in keeping down delivered costs. In any event the transportation component of oil delivered to Ontario will decline in relative significance, and modest rate increases may be absorbed.

Chapter 9

Capital Requirements of the Energy Sector

9:1 Any review of Ontario's energy capital requirements is dominated by the fact that the province derives more than 80 per cent of its energy externally. Thus the province is largely dependent upon energy investment decisions made elsewhere – in Alberta, the Northwest Territories or Pennsylvania. The situation therefore must be covered from an external as well as an internal viewpoint.

9:2 But over the next decades, indigenous supply will increase in relative significance as more nuclear capability is developed in the province. This capital intensive energy source will increase the role of domestic versus external capital needs.

9:3 The many implications of financing Canada's future energy developments are currently being widely debated. The main reason for this interest has centered around the development of Canada's frontier resources, principally in the Arctic Rim. Exploration and development in these hostile enrivons is very costly, and the major trunk lines required to move these resources to markets in Canada and the United States will comprise some of the largest capital-spending projects in history. Frontier resources are, almost by definition, capital intensive. Thus as future oil and gas supply leans more and more heavily on frontier resources, Canada's energy industries will require more capital per unit of energy delivered. This inevitable increase in capital intensity, along with strong demand pressures, will share the responsibility for steadily rising energy costs and prices.

9:4 Several authoritative estimates have been published recently concerning future capital requirements of Canada's energy industries. These range from $30 billion to $75 billion. Unfortunately, these estimates are not usually directly comparable because of the differing assumptions made and the periods covered. Also, different methods have been used. For example, one approach is to extend the historical relationship between industry capital spending and GNP, making allowance for the inevitable increase in the ratio during the next decade. Another approach is to cost individual sectors of the energy industry taking account of specific projects such as the James Bay hydro project or a Mackenzie Valley gas pipeline.

9:5 On the basis of this latter approach, a preliminary estimate of the capital requirements for all Canada's energy industries for the balance of the 1970s is $60 billion (1972 dollars. Of this total, roughly 50 per cent will be required by the electric power industry, new generating facilities accounting for approximately two-thirds and transmission facilities one-third. Approximately $15 billion will be required by the petroleum industry and $15 billion by the gas industry. It has been assumed in this estimate that the James Bay development will cost $6 billion with initial outlays beginning in 1974.

9:6 Petroleum exploration and development will account for approximately 45 per cent of the petroleum industry requirements with transportation requiring 38 per cent. The other needs will be for new refining and marketing facilities. In this total it has been assumed that an Arctic Rim oil pipeline would be started in 1978 with construction continuing into the 1980s, the total cost being $6 billion. The exploration and development component includes $100 million per annum for development of the Athabasca tar sands. From 1978 on, another $100 million per year will be needed for development of the Cold Lake heavy oil deposits.

9:7 Approximately half of the $15 billion required for natural gas development will be needed for new pipeline facilities. This includes $5 billion for a Mackenzie Delta pipeline and $600 million for development of an East Coast offshore pipeline, plus continuing expansion by TransCanada PipeLines. Exploration and development for natural gas will account for approximately 37 per cent and the remainder by new gas distribution facilities.

9:8 The magnitude of these requirements has caused great concern in many quarters when related to the questions of Canadian ownership; of the effect on the balance of payments; of the impact on the value of the dollar, etc. Until specific details are available on individual major projects (for example, the proposed import content of a Mackenzie Delta line), it is difficult to assess the likely impact of these requirements in detail.

9:9 However two qualifying points should be made. First, these capital requirements apply to development of resources for both domestic and export markets. Second, these are gross requirements and do not make allowance for the funds which can and will be generated internally by the participating companies. Estimates of this capability vary between 30 per cent and 40 per cent of total requirements. Applying a 35 per cent ratio to the $60 billion estimate reduces the requirement to $39 billion.

9:10 Finally, relating these gross requirements to GNP in constant dollars, we have a better indication of the ability of the Canadian economy to live with these volumes. Assuming real GNP to increase at an average annual rate of 5 per cent, the annual capital requirements for energy will average 5.5 per cent of GNP for the balance of the decade. The ratio increases from 4 per cent in 1973 to a peak just over 7 per cent of GNP in 1976 and 1977 to coincide with the maximum levels of activity for the proposed Mackenzie Delta line. Thereafter, the ratio declines but will be maintained by new major developments such as James Bay, and an oil pipeline from the Arctic Rim. If the net capital requirements only are taken, then the ratio to GNP will be substantially lower, averaging about 3.6 per cent.

9:11 The significance of these Canadian energy industry capital requirements to the province of Ontario is based on our heavy dependence upon energy from distant sources, specifically oil and gas from western Canada. The financing of the development of these energy sources in western Canada will have a direct bearing on the Ontario energy supply. Only in the 1980s, when nuclear power becomes significant, will Ontario's dependence on imported energy be reduced. However, by 1990 the province will still be importing approximately 70 per cent of its energy requirements.

9:12 Ontario's energy industries have their own capital needs, largely based on the requirements of Ontario Hydro. Combining Hydro's requirements with estimates for the other energy industries, the total Ontario capital needs will average roughly $1 billion per year for the decade. This is approximately 13 per cent of the Canadian total as estimated here. By comparison, Ontario's energy consumption represents 35 per cent of the Canadian total. This is another reflection of the province's dependence upon external energy sources and, as a corollary, upon external capital expenditures.

Chapter 10

Taxation and Energy in Ontario

INTRODUCTION

10:1 The production and consumption of energy in its various forms can be influenced and controlled by direct government regulation. Production and consumption patterns can also be influenced through the taxation system. Examples of direct government production controls are the spacing requirements for oil wells and prorating production among oil fields. In general, consumption has not been regulated except for safety and environmental purposes. Regulation of energy consumption is more likely to be indirect, through controls on the equipment rather than on the energy used by the equipment. With the exception of gasoline and diesel oil (primarily for transportation), Ontario does not tax energy consumption.

10:2 There is little evidence that taxation has been used by Ontario as a deliberate policy in order to influence demand for energy products. Electricity has received special consideration but this is probably due to the Hydro-Electric Power Commission of Ontario being a publicly owned non-profit organization.

ENERGY RESOURCE TAXATION

10:3 Ontario levies a number of fees and taxes on mining organizations over and above the normal tax on corporation income. The various licences, taxes

and fees include (a) The Mines Profits Tax; (b) The Mines Acreage Tax; (c) lease rentals on Crown lands; (d) exploratory licences of occupation in Lake Erie; (e) licences for gas and petroleum exploration in the North; and (f) gas leases. Water rentals are discussed later under a separate heading.

10:4 The Mines Profit Tax and The Mines Acreage Tax apply to uranium mines as to all other hardrock mines. In southern Ontario certain lands are exempt from these taxes even though active gas wells exist on them. Lease rentals of 25 cents per acre per annum are applied on mines which hold 10- or 20-year leases from the Crown. Some uranium mines do hold such titles on parts of the lands which they mine. Exploratory licences of occupation (for natural gas) in Lake Erie are issued for periods of up to three years; the rent is 15 cents per acre per annum plus performance of a stipulated amount of work during the period of the licence.

10:5 Licences for gas and petroleum exploration north of the 51st Parallel are issued at an annual fee of $250 per grid (75 or 80 acres). Gas leases of $1 per acre per annum are issued by the government and a royalty payment of 10 per cent on the prevailing price of natural gas is required.

10:6 While crude oil production has not been taxed, natural gas production until 1971 had been subject to a tax for most of this century. A tax of two cents per 1,000 cubic feet was first levied in 1907. Most of the tax was rebated but the proceeds were used to administer The Natural Gas Conservation Act. The tax also had the effect in the early days of the act of checking waste since gas not being "consumed" was subject to the full rate. This is surely one of the first examples of an energy conservation tax.

10:7 Following the Second World War, the natural gas tax was revised and the producer of natural gas became liable for a tax of two cents per 1,000 cubic feet for natural gas exported from Canada and a tax of one-half cent per 1,000 cubic feet for natural gas consumed in Canada. With the producer rather than the consumer being liable it could be considered an indirect tax beyond the jurisdiction of the province to levy. This uncertainty and the small revenue derived of $60,000 to $70,000 per year led to this section of The Mining Tax Act being repealed in 1971.

10:8 The various forms of energy are specifically exempt from the Ontario Retail Sales Tax with the exception of uranium. While uranium does not fall within any of the exemption categories it has been the policy not to tax uranium and it appears this policy should be legally sanctioned by an amendment to the act or by an Order-in-Council.

10:9 Ontario produces less than one per cent of its crude oil requirements and a little more than three per cent of its natural gas requirements. These sources are not large revenue producers for the province and any change in the current rates of tax would not make any appreciable difference in the provincial energy supply. Leases, taxes and royalties on natural gas and petroleum production generate about one-half million dollars in revenue.

TAXES ON ENERGY CONSUMPTION

10:10 Half a century ago, the highway-use concept was the sole rationale for provincial fuel taxation almost everywhere in Canada. Over the decades, however, this concept has been eroded in many provinces because fuel tax laws have been amended and extended reflecting the growing needs for general revenue. Nova Scotia and New Brunswick have departed the least from the highway-use concept. At the other end of the scale, energy taxation in British Columbia approaches the general revenue concept as does the province of Quebec. Ontario falls somewhere between these two concepts.

10:11 The gasoline tax was introduced in Ontario in 1925 and the preamble to the statute indicated that the purpose of the tax was to provide for "a fair contribution by the users of roads." In 1957, diesel fuel was divorced from gasoline tax under a new Motor Vehicle Fuel Tax Act. In the same year a "residual tax" was introduced for many off-highway (non-transportation) uses of gasoline. Recently the off-highway uses of diesel oil have been made subject to a similar tax. In 1969, the partial refund of tax for gasoline used in marine craft and in snowmobiles for pleasure was discontinued and a full tax was imposed for these uses.

10:12 Under The Motor Vehicle Fuel Tax Act, a 25 cents per gallon tax applies to all fuel (other than gasoline, aviation fuel or propane) used in all internal combustion engines, stationary or otherwise. Under The Gasoline Tax Act, the rate is 19 cents per gallon for gasoline and propane. Aviation fuel is taxed at the rate of three cents per gallon. Non-highway uses and industrial uses of these fuels qualify for a 13 cents gasoline and a 17 cents diesel fuel refund.[1] Fuel used in agriculture is subject to full tax refund.

10:13 In most provinces, including Ontario, anomalies and inconsistencies exist in the fuel tax laws. These have developed over the years as the tax authorities have met the need for revenue by attempting to superimpose a revenue-raising concept upon a highway-use concept of fuel taxation. Specific types of fuel and classes of use have tended to be selected at random to be taxed because of their revenue potential and without regard to the relationships among alternative types of fuel or among parallel classes of use. Again, other inconsistencies have arisen where some groups of fuels have been taxed under a retail sales tax while others have been taxed on a cents per gallon basis. The result has been that fuel tax rates have been unrelated through any standard measure common to all fuels, such as heating value or market value. On a few occasions, a reasonable relationship between two highway fuels appears to have arisen somewhat fortuitously. An interprovincial comparison of tax rates for major energy products and major use classes is set out in Table 10:1.

10:14 Imports of crude petroleum, coal, lignite and natural gas enter Canada free of duty. Specialized products, however, may have a tariff rate. Similarly, most energy products are exempt from the federal 12 per cent sales tax. The

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[1]With the exception of marine craft and snowmobiles used for pleasure, noted earlier.

major exception is fuel for use in internal combustion engines. No representations were made to the Advisory Committee on Energy with relation to federal taxation or import duties.

Table 10:1

Interprovincial Comparison of Tax Rates for Major Energy Products and Major Use Classes[2]

Energy Product and Use	*British Columbia*	*Ontario*	*Quebec*	*Nova Scotia*
A. Products Subjects to Tax Per Gallon				
Motor Vehicles				
Gasoline	15¢	19¢	19¢	21¢
Diesel	17¢	25¢	25¢	27¢
Aircraft	3¢	3¢	3¢	3¢
Farm Trucks				
Gasoline	15¢	19¢	19¢	21¢
Diesel	17¢	25¢	25¢	27¢
Farm Machinery				
Gasoline	3¢	full refund	exempt	exempt
Diesel	17¢	full refund	exempt	exempt
Internal Combustion Off-Highway				
Gasoline	3¢	6¢	3¢	exempt
Diesel	3¢	8¢	3¢	exempt
Heating				
Fuel Oil	½¢	exempt	exempt	exempt
B. Products Subject to Ad Valorem Tax				
Heating				
Electricity	5%	exempt	8%	—[4]
Gas	5%	exempt	8%	exempt
Coal	exempt	exempt	exempt	exempt
Lighting				
Electricity	5%	exempt	8%	—[4]
Manufacturing				
Electricity	5%	exempt	exempt	exempt
Gas	5%	exempt	8%[3]	—[4]

[2] Rates shown are those usually applied for the stated purpose, although many provinces have numerous exceptions.

[3] Refunds that portion of tax relating to goods exported from Quebec.

[4] Taxed on kilowatt hours rather than market value.

TAXATION AND ENERGY CONTENT

10:15 The Advisory Committee on Energy has a strong interest in the efficient use of our energy sources, in conserving our energy resources and in minimizing the environmental impact of energy use. The ideal tax statute should be positive in its application with regard to these matters. The tax should not encourage inefficiencies; it should not discourage conservation; neither should it encourage pollution of the environment; in fact, taxes might in certain circumstances be an appropriate method of encouraging conservation and reducing pollution.

10:16 The base on which each of the petroleum fuel taxes apply is the Imperial gallon, except in the case of some gaseous fuels which are taxed on a weight basis. The gallon, or its comparable weight, is easy to identify and easily measured but its use gives rise to a different tax load because various fuels do not have the same energy content.

10:17 With gasoline and aviation fuel, the product is easily identified and the tax is generally applicable. The tax is therefore collected at the refinery prior to distribution and those uses of gasoline for which full or partial exemption is allowed, are accommodated by a refund system.

10:18 On the other hand, a number of other fuels, such as diesel oils, heating oils and kerosene, are easily interchangeable among themselves and between taxable and non-taxable uses. Over 90 per cent of the use of these fuels is for tax exempt purposes such as heating and lighting. The present method is to collect from numerous licensed wholesalers and retailers who operate as agents for the province. In some cases, the tax has to be collected directly from the consumer after the use has been identified. The single most troublesome problem involved in the collection of tax is identifying whether it is being used for a taxable or non-taxable purpose. This is particularly so when there are many tax exempt uses and the tax is collected through a system whereby there is little way of knowing what the end use really is.

10:19 The present Ontario fuel tax statutes tend to discriminate against the use of propane as a motor fuel. Propane is taxed at the same rate as gasoline but it does not have an equal energy content. Therefore, it is more expensive to use than gasoline. On the other hand, propane is a cleaner fuel than gasoline and contributes less pollution to the environment. This matter ought to be reviewed in Ontario.

10:20 A growing number of jurisdictions in North America encourage the application of gaseous fuels, principally propane, by means of a tax incentive. The greatest advantage to the environment comes from use of liquid propane gas by fleet vehicles operating in and around urban areas with high vehicle density. However, this application will not be promoted by the companies concerned if by using propane their costs are higher than they would be by use of gasoline.

10:21 California has eliminated the state fuel tax (six cents per gallon) on vehicles equipped with gaseous fuel systems. The reduction in fuel costs is a substantial incentive. Other states which have similar tax incentives include

Washington, nine cents per gallon; New Jersey, three and one-half cents; Kentucky, nine cents; and New Mexico, nine cents per gallon. Several additional states have various forms of incentive legislation in force or pending. In Great Britain, the liquid propane gas fuel tax is 50 per cent that of gasoline. It is noted that the Ontario Ministry of Government Services maintains a fleet of propane-fuelled vehicles.

10:22 Energy content can be measured by comparison of the British thermal unit content of the fuels;

Table 10:2

Comparison of Energy Content and Tax Rate

Fuel	*Energy Content per gallon*	*Ontario Tax per gallon*
Gasoline	147,000 Btu	19 cents
Diesel Oil	163,000 Btu	25 cents
Propane	110,000 Btu	19 cents

10:23 The energy content of a gallon of propane is approximately three-quarters the energy content of a gallon of gasoline. For the tax rate to be equal, the appropriate level of taxation would be about 14 cents per gallon.

10:24 A major consideration in any change in tax levels must be the impact on revenues to the taxing authority. The revenues derived from administration of The Gasoline Tax Act and The Motor Vehicle Fuel Tax Act are substantial.

Table 10:3

Ontario Taxable Gallons and Revenue

Fiscal Year 1970-1971

Fuel	*Net Taxable Gallons 000*	*Revenue $000*
Gasoline and Propane	2,060,732	375,778
Diesel	141,843	33,334

10:25 The loss of revenue resulting from a reduction of the tax rate for propane and liquefied natural gas would be relatively small because of the limited use of these fuels for operating motor vehicles. Conventional engines must be converted before use is possible and the products are not readily available everywhere.

10:26 The use of the British thermal unit, or a suitable metric unit, as the fuel tax base, would be an easily measurable property for all fuels whether solid, liquid, gas or electricity, and readily applied not only to petroleum fuels already taxed but also to any alternative fuels which may come into use in future.

TAXES ON UTILITIES

10:27 A public utility owned and operated by the Crown is not subject to many of the taxes levied on a privately owned organization. The private utilities competing in this market find themselves at a tax disadvantage and it is for this reason that the federal government turns over to the provinces 95 per cent of the federal income tax paid by privately owned utility corporations in respect of their income arising from the generation or distribution and sale of electrical energy, steam and gas. The provinces can in turn pass on the federal tax transfer to the industry and in addition exempt the private utilities from the provincial corporation income tax.

10:28 Alberta rebates to the industry not only the 95 per cent of the federal tax but also 100 per cent of the provincial income tax levied on private utilities. In Ontario, it was decided that the federal transfer, which amounted to $10 million in 1971, be retained by the province for general purposes.

WATER POWER RENTALS

10:29 Water power rental agreements between the province of Ontario and various users have existed and evolved over many years. The administration of the rental agreements can be described by dividing them into three categories:

(a) Leases administered by the Ministry of Natural Resources. There are 28 lease agreements administered, 19 of which have expired and are in the process of renegotiation. Total revenue derived in 1970/71 from these agreements was about $700,000.

(b) Agreements with Ontario Hydro, Hydro-Quebec and The Power Authority of New York State. The agreement with Ontario Hydro levies a rate considerably lower than the rates imposed through the leases in the first category above. Ontario Hydro paid about $8,000,000 to the province in the calendar year 1970 under the terms of this agreement, and another $925,000 to The Niagara Parks Commission.

The Water Power Rental Agreement with Hydro-Quebec was signed in 1943 for the period of 999 years. Terms of the agreement are subject to review every 25 years and there were no changes made when this review period passed in 1968. The rate charged is considerably lower than that charged to Ontario Hydro.

The agreement between The Power Authority of New York State and Ontario entitles each to 50 per cent of boundary waters.

(c) Special agreements with The Canadian Niagara Power Company and The Ontario-Minnesota Pulp and Paper Company.

10:30 For historic and other reasons, there is a lack of uniformity and therefore probably some inequity in the application of water power rental rates. It should be possible to achieve greater uniformity for a common resource, water power, which produces a common product, electricity. A centralized administration would facilitate the application of a common rental policy.

10:31 As for the determination of a proper rental rate, some weight must be given to the fact that for many decades water power was the only significant source of electricity. It does not easily lend itself therefore to a solution whereby water rental rates are related to fuel costs for thermal generation. Furthermore, the recent introduction of nuclear fuel at a cost substantially below that for fossil fuel is an additional complication.

Chapter 11

The Role of Nuclear Power in Ontario

INTRODUCTION

11:1 It is not generally realized that the first nuclear reactor to operate outside the United States was a heavy water reactor located in Ontario at Chalk River. Canada, through historical circumstances, was launched into the research and development of "heavy water" reactors in 1943.

11:2 For nearly twenty years, the Canadian nuclear research and development effort has been devoted to the objective of economic nuclear (electric) power utilizing natural uranium fuelled, heavy water moderated, reactors. The Crown corporation responsible, Atomic Energy of Canada Limited, now administers assets of $500 million and, over its lifetime, has administered a program of research and development approaching one billion dollars.

11:3 With the development of electricity in the latter part of the 19th century, Ontario was fortunate to have at its doorstep one of the greatest sources of this new form of energy, Niagara Falls. Development began immediately and the province continued to draw increasing amounts of electric power from Niagara for the next 50 years. The combined capacity of all the Niagara plants is over two million kilowatts.

11:4 Abundant low cost hydro-electric power favourably located, supported and accelerated the economic growth and expansion of the provincial economy.

While it is not possible to give an accurate measure of the significance, certainly in the absence of hydro power it is doubtful if economic development would have occurred to the same extent. Low-cost power almost immediately attracted power-intensive industries to the Niagara Peninsula and, indeed, these industries have continued there although with increasing difficulty as the original cost advantage has disappeared. Overall, however, electric power rates in Ontario have been and continue to be among the lowest in the world.

11:5 Lacking supplies of the fossil fuels, and with few remaining water sites, Ontario once again found within its borders abundant quantities of a new energy source for the second half of the 20th century – and probably for a good part of the 21st century as well. With the arrival of the nuclear age, large uranium discoveries were made in Ontario.

11:6 As with water power, it is logical that Ontario uranium should be a cornerstone for provincial energy policy. The same elements continue to be present: a system for generating electric power (a nuclear reactor instead of water power) characterized by a relatively high original capital cost but offset by very low fuelling costs over the life of the plant.

11:7 Logic would further dictate that Ontario should take advantage of the Canadian nuclear research effort which has been sustained over such an extended period and directed toward one objective – electric power from a nuclear reactor at a competitive price. However, the uranium resource can benefit Ontario through sales abroad and if nuclear power is not competitive as a source of electricity it should not be a major element in Ontario energy policy.

THE FISSION PROCESS AND NUCLEAR POWER

11:8 Natural uranium contains 0.7 per cent U-235 (1 part in 140) which is the only abundant naturally occurring fissile material. U-235 is fissionable with slow neutrons and the process is accompanied by the release of a large quantity of energy. Other fissionable materials are produced by neutron capture by an atomic nucleus of uranium 238 or thorium 232. The resultant nuclear fuels are, respectively, plutonium 239 and uranium 233.

11:9 To increase the probability of fission, neutrons must be slowed down or "moderated". The best moderating materials are ordinary water (H_20), heavy water (D_20), graphite or beryllium. The properties of heavy water make it an exceptionally good moderating material. Thus a fuel core containing fissionable material, may sustain a nuclear chain reaction in which the U-235 atoms split when bombarded by neutrons, releasing energy plus additional neutrons.

Table 11:1

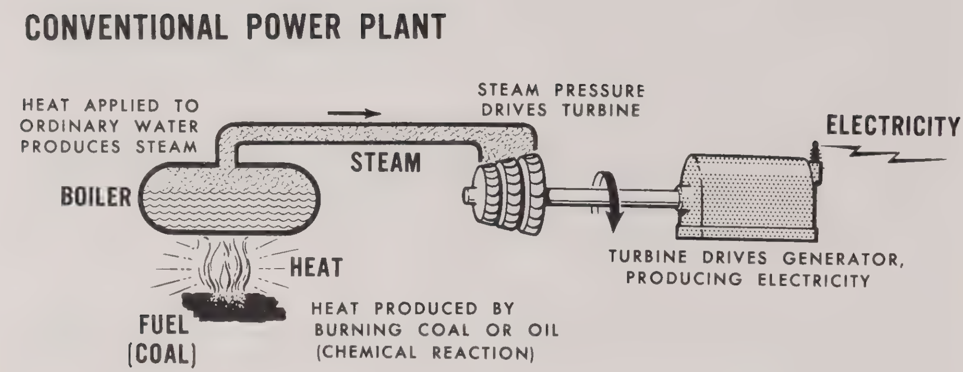
Relative Moderating Ratios

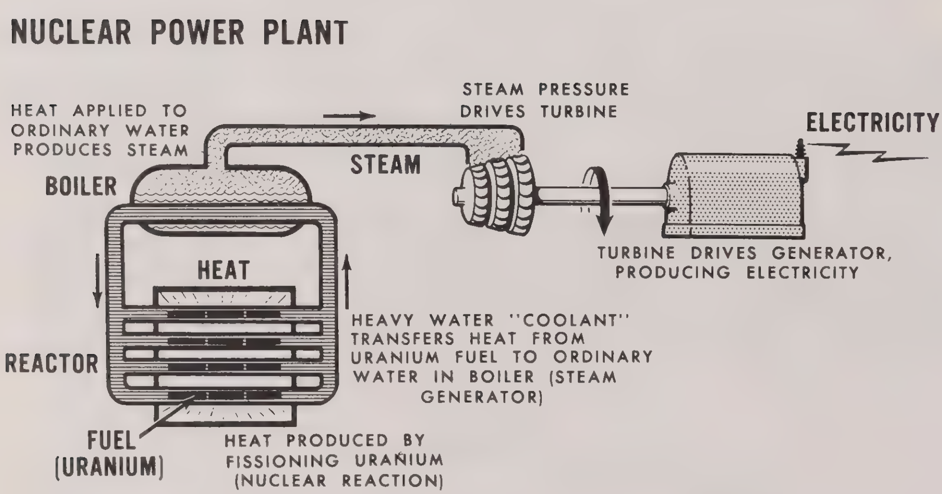
Ordinary Water (H_20)	1
Beryllium	2.5
Graphite	2.8
Heavy Water (D_20, reactor grade)	33.0

Source: *Heavy Water, A Layman's Guide*, Atomic Energy of Canada Limited, PP-8, 1969.

Figure 11:1

Thermal Electric Power





11:10 The heat released in the reactor compares with the heat created by burning fossil fuel, either coal, oil or gas, in the firebox of a boiler. The remainder of a nuclear power station is made up of the conventional steam turbines and generators as in a fossil-fuelled thermal station.

11:11 Thermal neutron reactors thus have three essentials: the fuel, the moderator, and a coolant to withdraw the heat generated by the fission fragments retained in the reactor.

11:12 The development of nuclear power technology is proceeding by way of three basic types of nuclear power systems. The first are the thermal converter reactors which are now being installed by electric power companies and which will continue to be the dominant type for the next decade at least. Second are the fast breeder reactors which, if developed as economic power sources, will be widely adopted partly because they can use uranium more efficiently. Finally, in the more distant future, fusion reactors may be developed.

THE CANDU NUCLEAR SYSTEM

11:13 The Canadian nuclear power system which has been successfully developed over the past two decades is known as CANDU (Canadian Deuterium Uranium). The nuclear reactor is a stainless steel tank through which run horizontal tubes of a zirconium alloy. Inside these tubes run a second set of pressure tubes which contain the several thousand bundles of uranium fuel. The reactor vessel is filled with heavy water (the moderator) and a separate circuit of heavy water is pumped through the pressure tubes to transfer the heat from the fuel. This heavy water coolant is then passed through tube-in-shell heat exchangers where it gives up its heat to turn ordinary water into steam. Steam then leaves the reactor building and is fed to the turbine generator. Variations of this design are being explored; but, basically, this description fits the three plants now in the Ontario system, that is, Douglas Point, Pickering and Bruce.

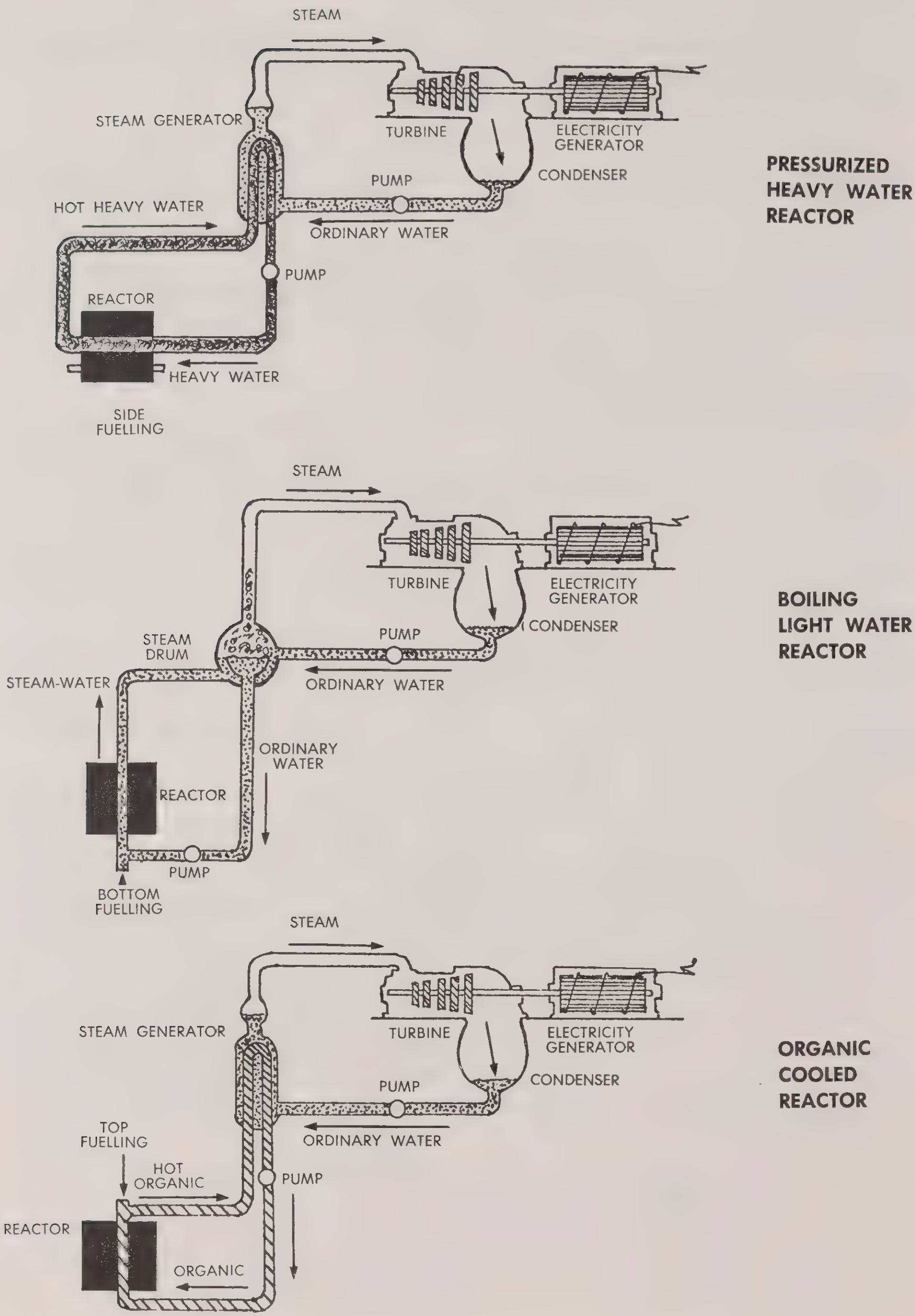
11:14 Its validity as a competitive power generating plant is predicated on: (a) *neutron economy* (heavy water and zirconium alloy structural material, to minimize neutron wastage) in order to provide flexibility in choice of fuelling scheme. The Canadian reactors can burn natural uranium, or, with some form of enrichment, thorium; (b) *pressure tube design* (as opposed to a pressurized vessel) which separates the coolant from the moderator; (c) *coolant options* which are made possible by the separation of the coolant from the moderator.

11:15 The reactors, in use and under construction in Ontario at present, use pressurized heavy water in an indirect cycle. Experience is being gained at Gentilly in Quebec with light water as the coolant in a direct cycle. An organic (terphenyl) heat-transport system is under development in the AECL reactor at Whiteshell, Manitoba.

11:16 Taking advantage of the good neutron economy of deuterium (heavy water) as a moderator, a reactor built on a modular pressure-tube principle can achieve exceptionally low fuel cost using natural uranium on a once-through cycle. The Pickering nuclear station has a fuel cost of around 0.9 mills per kWh. The fuel cost for a coal station is about 4½ mills per kWh – five times greater.

Figure 11:2

Canadian Heavy Water Reactor Systems



11:17 A notable technical achievement has been the development of fuelling machines which refuel the reactors while they continue to operate. The technique of on-power fuelling is made possible by the use of pressure tubes (rather than a pressure vessel) and fuel bundles. The fuelling machines by remote control insert a fuel bundle at one end of the reactor and capture a spent bundle at the opposite end. On-power fuelling allows maximum efficiency in the use of the fuel. It also allows maximum operating time since the reactor is not shut down for periodic fuel changes. No other power reactor system can change fuel without shutting down.

11:18 There are eight nuclear power stations using the Canadian system in operation or under construction for a total capacity of 6000 megawatts.

Table 11:2

CANDU Type Heavy Water Nuclear Power Plants

	Megawatts electric	*Reactor Type*	*Owner/Operator*	*Start-up*
Domestic				
NPD (Rolphton)[3]	25	CANDU-PHW[1]	AECL/Ont. Hydro	1962
Douglas Point	200	CANDU-PHW	AECL/Ont. Hydro	1967
Pickering	4 × 500	CANDU-PHW	Ont. Hydro	1971-3
Gentilly-1	250	CANDU-BLW[2]	AECL/Hydro-Que.	1971
Bruce	4 × 750	CANDU-PHW	Ont. Hydro	1976-9
Foreign				
KANUPP[3]	137	CANDU-PHW	Pakistan	1971
RAPP	2 × 200	CANDU-PHW	India (Rajasthan)	1972-4
MAPP	2 × 200	CANDU-PHW	India (Madras)	1975-?

[1]Pressurized Heavy Water
[2]Boiling Light Water
[3]Designed and built by Canadian General Electric Company Limited

LIGHT WATER REACTOR SYSTEMS

11:19 Light water reactor systems have been developed by the United States and they have had the advantage of the facilities and research associated with the large military program. For example, one of the most successful reactor types, the Pressurized Light Water Reactor (PWR) is based essentially on the nuclear reactors designed for naval vessel propulsion. The second major reactor type in commercial use in the United States is the Boiling Water Reactor (BWR).

11:20 In the Boiling Water Reactor, light water (H_20) serves as both the moderator and the coolant. The water is converted to steam directly in the reactor

vessel. It is fuelled with enriched uranium clad in zirconium tubing as is the Pressurized Water Reactor. Similarly, the PWR is moderated and cooled with ordinary water. In the PWR, however, the coolant is kept under pressure and heat is transferred to a secondary system where, in a separate system, water is converted to steam for use in turning the turbine.

11:21 Because ordinary water is used as a moderator for these reactors, the fuel must be enriched up to 3 per cent U-235. Large uranium enrichment plants constructed for military purposes make enriched uranium readily available. Whereas the Canada system uses pressure tubes, the light water reactors are completely enclosed in a pressure vessel. These two major types, the BWR and the PWR, have been ordered by many electric power utilities in the United States and at mid-year 1972, 26 were in operation with a combined capacity of nearly 12,000 megawatts.

11:22 In addition, a total of 110,000 megawatts of nuclear electric power is under construction or on order in the United States. The largest operating unit today is about 800 megawatts electric with units of over 1100 megawatts under construction.

11:23 These reactors also dominate the international market. By the end of 1971, about 50 light water reactors totalling more than 26,000 megawatts were in operation, under construction or on order in thirteen countries.

OTHER REACTOR SYSTEMS AND NATIONAL PROGRAMS

11:24 The United Kingdom has long been a world leader in the amount of electricity produced by nuclear reactors. The nuclear systems which have been developed there are based on graphite as the moderator and carbon dioxide gas as the coolant or heat transfer system. These reactors are contained in large concrete pressure vessels. In the first series of power reactors natural uranium metal encased in magnesium alloy (Magnox) cans is used as fuel. In the later series called the Advance Gas-cooled Reactors (AGR), enriched uranium oxide in stainless steel tubes is used as fuel.

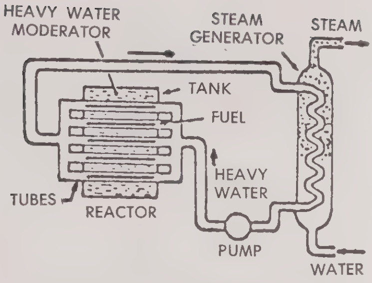
11:25 The first prototype station at Calder Hall has been operating for fifteen years and, overall, more than two hundred reactor years of experience have been gained from eleven stations which are in operation. The second United Kingdom nuclear program includes five stations now under construction. These stations use enriched fuel. Thus, the United Kingdom has 11,000 megawatts of nuclear capacity in use or under construction.

11:26 The type to be included in the next phase of nuclear development is not known at the time of writing and the whole nuclear development program of the United Kingdom is under review.

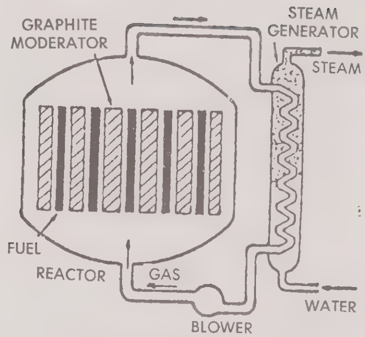
11:27 Most other European countries and in particular Germany, Italy and France, have moved strongly in the direction of nuclear power during the past decade. It is estimated that installed nuclear capacity in Western Europe will

Figure 11:3

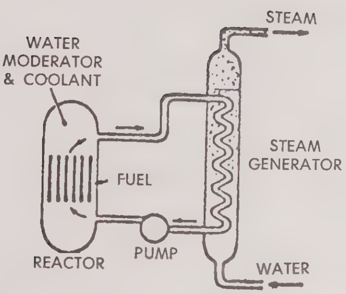
Major Reactor Types



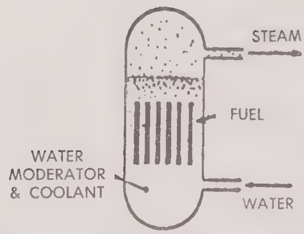
CANDU HEAVY WATER REACTOR



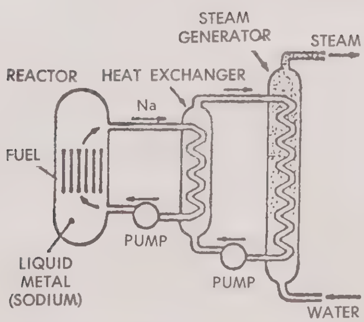
U.K. GAS-COOLED REACTOR



U.S. PRESSURIZED-WATER REACTOR



U.S. BOILING WATER REACTOR



LIQUID-METAL-COOLED FAST REACTOR

reach 35,000 megawatts electric by 1975. Japan, with a fast growing energy demand, had four medium-sized stations in operation during 1971 with nine nuclear plants under construction for a total of 5800 megawatts electric.

11:28 Up to the present time, four reactor types have had substantial operating experience. First are the graphite moderated gas-cooled systems developed by the British and also by the French. There are the two American light water reactors, the boiling water reactor and the pressurized water reactor, both of which use enriched fuel. The fourth is the Canadian natural uranium heavy water moderated reactor system.

11:29 Both Sweden and West Germany have light water reactor programs independent of the United States. Also, West Germany's development program includes a pressurized heavy water reactor, while the United Kingdom is presently considering further development of its steam-generating heavy water reactor (SGHWR). The SGHWR bears some similarity to the Canadian reactor system in that it is a pressure-tube heavy-water moderated system using light water as the coolant. A High Temperature Gas-cooled Reactor (HTGR) has been developed in the United States based on helium as the coolant. It is graphite moderated and fuelled by an enriched uranium-thorium combination. One United States utility has recently ordered a 2300 megawatt HTGR station.

11:30 With several types already proven for commercial operation, emphasis in many countries is shifting to the development of the fast breeder reactor rather than to the development of additional thermal type reactors. To sum up, therefore, the BWR and PWR not only dominate the market in the United States but also dominate the world market, being in operation and under construction in most countries which have nuclear programs.

11:31 There are many other possible types of thermal converter reactors which at one time or another have been looked into by research programs in the United States, the United Kingdom or the major European countries. However, it now appears doubtful if these will ever achieve more than limited commercial acceptance.

THE MATTER OF COMPARATIVE COSTS

11:32 The kind of electric power stations to be built in order to meet future demand is a major concern of practically all electric power utilities. There are uncertainties concerning the long-term supply of petroleum and natural gas, and coal often faces problems of meeting pollution control standards. Uranium, on the other hand, has the advantage of assured long-term supplies, small volume, and a negligible volume of waste products.

11:33 In most parts of the world therefore, including Ontario, the predominant form of electric power generation in future will be based on the use of uranium. The problem is to select the most suitable type of reactor system. For Ontario, the question arises as to whether or not there are advantages to be gained by

introducing a nuclear system other than CANDU or one of its variations. Our review has indicated that the most likely alternative would be a light water reactor from the United States.

11:34 On the subject of capital costs, it is difficult to get good comparative statistics, or indeed to draw even broad cost comparisons between CANDU and BWR or PWR. Original cost estimates of most nuclear stations have escalated so that the actual final cost differs substantially from the original estimate. The cost escalation varies with changes in interest rates and with the lengthening of the total construction time. These and many other factors must be taken into account.

11:35 The average capital cost of a 1000 megawatt electric nuclear power plant of the light water variety ordered in the United States in 1971 was $310 per kilowatt, excluding the cost of the site and the cost of the fuel. While the Pickering and United States estimates are not directly comparable because the latter excludes the cost of enriched fuel, it is possible to make a rough comparison by equating the discounted cost of enriched fuel with the cost of natural fuel and heavy water. By deducting the cost items, fuel and heavy water, in Table 11:4, we get a resultant cost per kWe equal to $309, which falls in the middle of the cost range shown for the United States in Table 11:3. On this basis, Pickering costs compare very favourably with the average cost for United States light water reactor stations.

11:36 When the lifetime of the plant is taken into consideration, the extremely low fuelling costs of the CANDU reactor become a factor of major significance. The average cost of a unit of electricity over the lifetime of the plant will depend on the capital cost and also on the long-term cost of the fuel. It has been pointed out that CANDU fuel costs are so low there is a parallel with water power as a means of generating electricity. In the case of enriched-fuel reactors, fuel costs are an important element in the cost of electricity and long-term enriched fuel costs are uncertain.

11:37 Overall, therefore, a somewhat higher capital cost for a CANDU generating station is offset by lower operating costs. Unit energy costs may be higher or lower than energy from a light water nuclear station.

11:38 It has been argued that as the amount of nuclear energy capacity increases in the total electric system, a mixture of reactor types will provide insurance should a major fault develop in one type. The Magnox reactors in the United Kingdom, for example, have developed unexpected corrosion problems, as have the later AGR's. For the next decade, however, during which nuclear stations do not dominate in the total Ontario Hydro system, the introduction of a new nuclear type (not just a variation of the CANDU reactor) is felt to be unnecessary. A further ten years of operating experience added to the ten years of design and operating experience already achieved with CANDU reactors will by that time provide the basis for greater confidence.

Table 11:3

Light Water Nuclear Costs Mid-1971 Orders

	Dollars per Kilowatt
Land	1
Structures and Improvements	26-44
Reactor or Boiler Plant Equipment	49-57
Turbine-Generator Plant	58-67
Miscellaneous Electric and Power Plant Equipment	16-20
Other Costs (incl. Spares, Indirect, Cooling Towers and Control)	55-66
Interest During Construction	50-62
Contingency	10-13
TOTAL COST, NO ESCALATION	$265-330

Source: *The Nuclear Industry 1971,* United States Atomic Energy Commission

Table 11:4

Capital Cost of Units 1-4 Pickering Generating Station

	Thousands 1971 Dollars	
1. Site and Improvements	5,100	1%
2. Buildings and Structures	73,000	10%
3. Reactor, Boiler and Auxiliary	102,100	14%
Fuel	8,700	1%
Heavy Water	119,300	16%
4. Turbine Generator and Auxiliary	66,200	9%
5. Electrical Power Systems	32,400	4%
6. Instrumentation and Control	25,900	3%
7. Common Processes and Services	32,000	4%
TOTAL DIRECT COST	464,700	62%
8. Construction		
Operation and Maintenance	48,400	6%
Engineering	73,600	10%
Interest During Construction	101,800	14%
Contingencies	6,700	1%
Other	51,000	7%
GRAND TOTAL	746,200	100%
Cost per kWe	$370/kW	

Source: Adapted from Ontario Hydro figures.

NUCLEAR FUEL

11:39 The uranium reserves in Ontario are one of our most important natural resources. However, the nuclear industry is a relative newcomer and the basic ingredient of the industry – uranium – often is still considered as simply another mineral. Nuclear power will probably be one of the principal methods used for electric power production in Ontario for many decades. Further, there is every evidence to suggest that the demand for electricity will continue to increase for many years. Accordingly, careful attention should be given to our own long-term uranium fuel requirements and to the method adopted to ensure that a supply is available at the lowest cost.

11:40 At present, the total committed nuclear capacity (Pickering and Bruce) in Ontario is 5000 megawatts. If, for instance, only three more nuclear stations of comparable size are added, the lifetime (thirty years) uranium requirement for these five plants will be about 70,000 tons of U_3O_8. On this basis, the annual demand for uranium fuel for Ontario electric power plants will have risen to 5,000 tons by the year 2000.

11:41 With the rapid increase in nuclear generating capacity throughout the world will come a correspondingly rapid growth in the demand for nuclear fuel. The present family of thermal converter reactors will depend on uranium, with the probability that the plutonium produced will be recycled. However, the Canadian CANDU reactor has the flexibility to use a thorium or plutonium fuel cycle. The high temperature gas-cooled reactor (HTGR) being developed in the United States has a uranium-thorium fuel cycle.

11:42 Development work is proceeding toward the objective of plutonium recycle for all nuclear reactors. The plutonium will be extracted from the spent fuel and recycled through the reactor as a component of the new fuel. Forecasts of uranium requirements are usually based on the assumption that plutonium will begin to be recycled in the late 1970s. Substantial amounts of plutonium will be produced.

Table 11:5

Kilograms of Plutonium Recoverable per Year

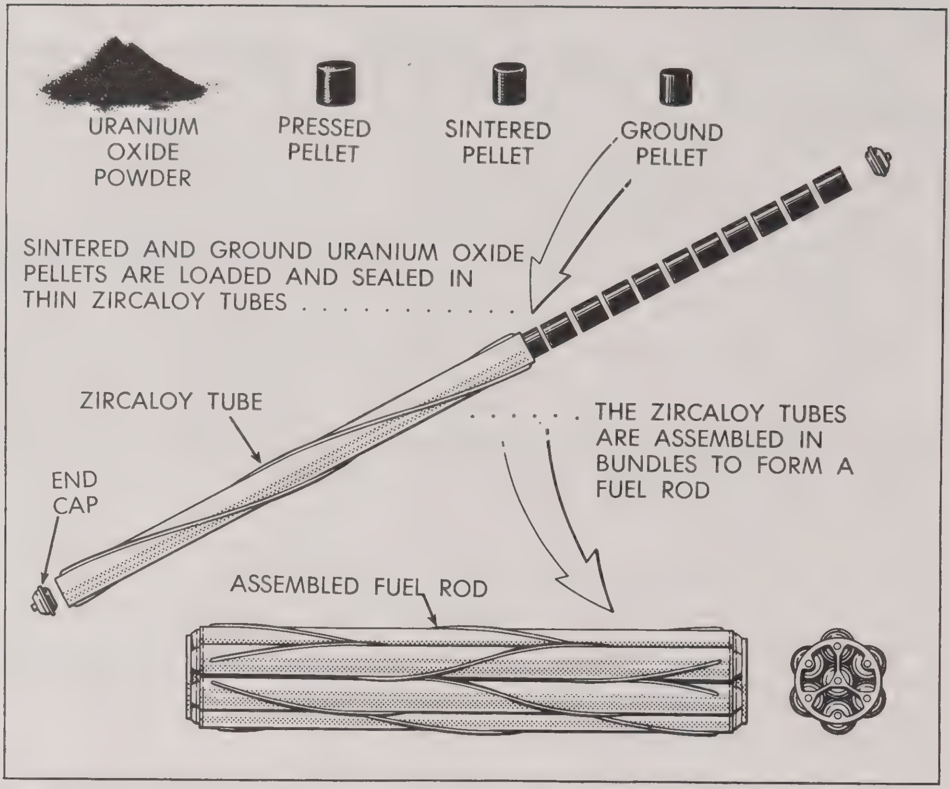
Year	*United States*	*Rest of World*
1972	500	3,800
1975	4,000	5,500
1980	15,600	16,200
1985	37,100	37,400

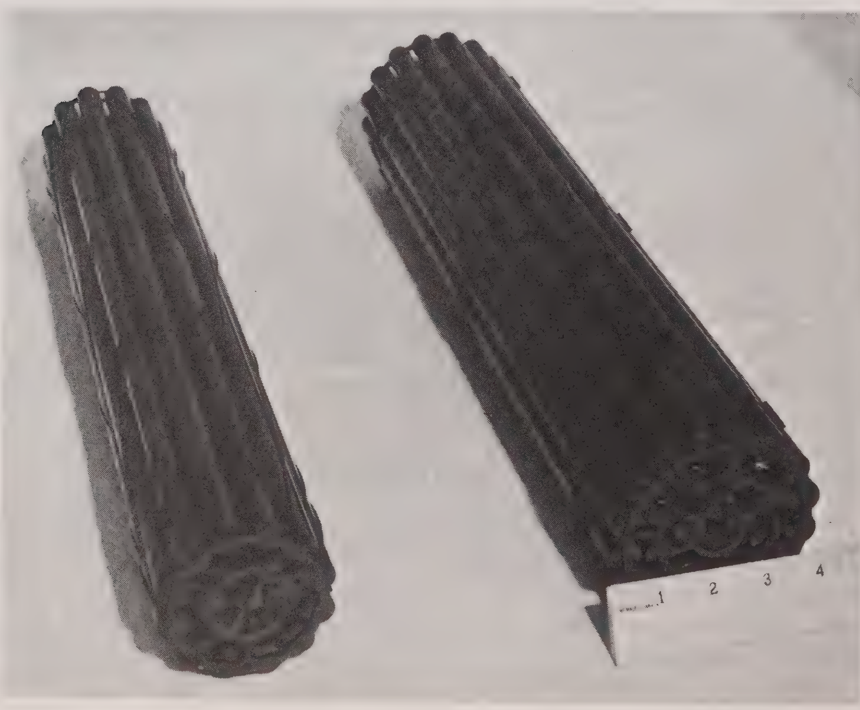
Source: *The Nuclear Industry 1971,* United States Atomic Energy Commission

11:43 However, a period of years must elapse after the initial start-up of a reactor before plutonium is produced, recovered and fabricated into a new fuel element. Increasing quantities of uranium will continue to be required through 1985 and the impact of plutonium will be relatively small for the next fifteen years at least.

Figure 11:4

CANDU Natural Uranium Fuel





11:44 Installed nuclear capacity in 1980, excluding the communist countries, will be about 300,000 megawatts. This will grow rapidly to an estimated 600,000 megawatts by 1985 and will require approximately 1,000,000 tons of uranium fuel cumulative to 1985, including the use of recycled plutonium. The increasing demand for uranium will put pressure on the supply and tend to increase the price of uranium. The cost of uranium is a significant factor in the total fuel costs of enriched uranium nuclear plants. Concern for long-term supply and for rising costs has spurred the search for new approaches to nuclear power. These factors have made the breeder reactor attractive in the United States.

11:45 Canada has specialized in nuclear fuel development from the beginning and particularly since the adoption of the pressure tube method of fuelling. A wide range of uranium products is available from the Eldorado Nuclear Limited refinery at Port Hope which has been in operation since 1933. It processes the uranium "yellow cake" coming from the mines into the various forms of uranium required by the fuel industry, such as ceramic-grade uranium dioxide powder and uranium hexafluoride.

11:46 A fuel fabricating industry has also been established to complete the fuel production cycle. By the end of 1970, for example, the Canadian fabrication industry has handled more than 500 tons of uranium which represented a production of 30,000 bundles and more than 700,000 individual fuel elements. More than ten million fuel pellets were used. Fuel fabrication faciilties are being fully utilized and the industry will be expanding to meet future requirements as new nuclear plants are committed.

11:47 The substantial difference in the cost of fuel fabrication for the Canadian CANDU system and the United States PWR system is shown in the following table, exclusive of the relatively high cost of enriched uranium.

Table 11:6

Comparison of Fuel Fabrication Costs for CANDU and PWR Systems

Item	*Enriched Uranium PWR*	*Natural Uranium CANDU*
	(1970 $/KgU)	
UO_2 – powder preparation	13.02	
Pelletization	15.10	8.00
Materials other than UO_2	29.65	
Encapsulation and assembly	17.62	19.65
Shipping	0.72	0.11
Total	76.11	27.76

Source: L. R. Haywood, et al. *Fuel for Canadian Power Reactors.* Paper presented at the Fourth United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1971.

THE MATTER OF URANIUM ENRICHMENT

11:48 Since the early years of the Canadian nuclear program there has been controversy in Canada over the subject of enriched uranium. Several factors have been involved. First, there are those who disagree with the Canadian approach to nuclear power based on natural uranium, particularly in view of the fact that this was the sole system being developed. Others, considering that the enrichment process required vast quantities of electric power, looked to the untapped water resources in northern Canada and argued that Canada should exploit its economic advantage in this regard. Finally, there is the economic argument that, since Canada holds vast reserves of uranium, we should not export the raw material but should upgrade it in Canada and sell the more highly processed product abroad.

11:49 These and other arguments in favour of a Canadian enrichment industry have not changed over the years. Recently, there has been renewed interest on the part of several countries who, looking ahead, can see a growing requirement for enriched uranium to fuel their own nuclear power plants and who wish to have an assured supply under their own control. However, because of the great capital cost of an enrichment plant using the gaseous diffusion process and because few countries can foresee a requirement for the full output of such a plant, the subject is still in the discussion and proposal stage.

11:50 For Ontario the major argument relates to upgrading our uranium resource, similar to the policy which applies to other minerals. However, considering the vast quantities of electric power which are required by the gaseous diffusion process and the exhaustion of unused large resources of hydro power in Ontario, we can make no special case for a uranium enrichment facility of this type to be located in the province. Proposals put forward by foreign governments and by private interests are based on the low-cost power potential of northern sites located in other provinces.

11:51 One can predict a growing world demand for enriched uranium and there is general agreement that additional enrichment capacity will be required after 1980. In order to market a competitive product, any new facility will have to be large, with a correspondingly large capital cost plus the associated expenditures for electric power facilities.

11:52 The technology of gaseous diffusion is reasonably well known since, in addition to the United States, small plants exist in the United Kingdom, France, and large ones in the Soviet Union and China. To illustrate the size of the operations and the investment required, the three enrichment facilities in the United States had an original cost of more than $2 billion and at full capacity during the 1950s required about 55 billion kilowatt hours of electric power a year, an amount equal to the total electrical demand in Ontario in 1967. A large gaseous diffusion plant requires a power plant the size of Pickering (2000 MW) in order to operate.

Figure 11:5

Fuel Cycle of Reactor Using Enriched Fuel

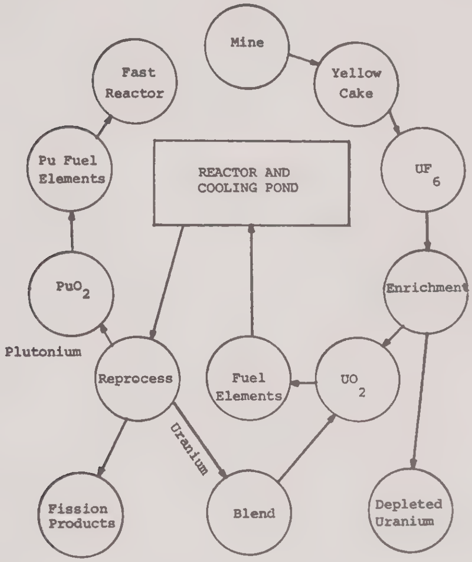
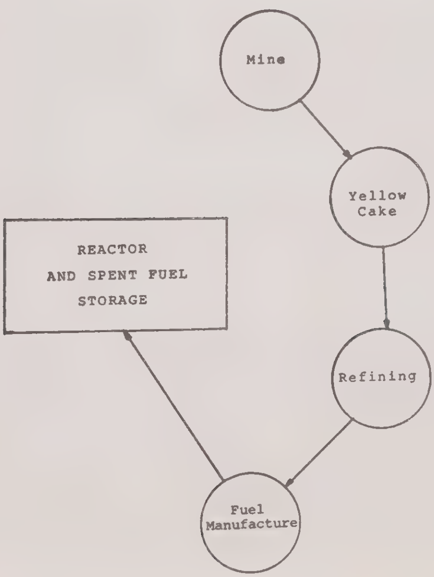


Figure 11:6

Fuel Cycle of Reactor Using Natural Uranium



11:53 It is not surprising, therefore, that research has been under way in order to find an alternate method of achieving enrichment. The most promising, which has been under development for the past fifteen or so years, is the gas centrifuge process. This process is now in an advanced stage of development and in 1970 a tripartite agreement by West Germany, the Netherlands and the United Kingdom has led to the commitment of pilot centrifuge plants. The centrifuge process has a major advantage over the diffusion process in that plant expansion is possible through incremental growth. Thus, capital investment can be staged over a series of years as the market develops. In addition, the power requirement is about 15 per cent that of the gaseous diffusion process. However, at present, the capital cost of a centrifuge plant is two to four times higher than that of a diffusion plant, per unit output of enrichment. If the centrifuge process continues to show promise, it may cast a shadow over plans for the necessarily large investment which must be made for new gaseous diffusion facilities. There is a view, however, that it could complement the gaseous diffusion process.

11:54 The United States domestic demand for enriched uranium is a matter of some interest. The three existing United States enrichment plants when operated at their total capacity (using about 6,000 megawatts of electric power) have a total separative capability of about 17 million units per year. This will be increased to 27 million units as a result of an improvement and uprating program now under way. Annual requirements in the United States are expected to reach 70 million units about 20 years hence or triple the capacity of the existing plants.

11:55 While uranium is our most valuable fuel resource, it is also a mineral which should be upgraded as much as possible before it is exported. The CANDU reactors in many cases can benefit from some slight enrichment of the fuel. Therefore, the possibility of locating a uranium enrichment facility based on the centrifuge process in the province should be kept under review.

NUCLEAR FUEL REPROCESSING FACILITIES

11:56 Nuclear fuel, after two or three years in the reactor, has built up fission products and reduced its fissile material so that it is no longer efficient. The economics of the Canadian CANDU nuclear power system are so favourable that no value is given to the used fuel. For nuclear systems using enriched fuel, however, the spent fuel is usually reprocessed and values are reclaimed from this material. The plutonium and the remaining enriched uranium are recovered for further use or sale.

11:57 United States nuclear economics includes a plutonium credit as part of the fuel costs of the order of 0.25 mills per kWh. Therefore, it is necessary to find a use for the plutonium in order to obtain the credit. For each 1,000 megawatts electric of installed capacity approximately 180 kilograms of fissile plutonium are produced per year. Accordingly, utilities are working on plans either to recycle the plutonium back into the reactor, or as an alternative, to sell it on the open market. The use of plutonium as a nuclear fuel is still in an early stage of development.

11:58 The Canadian natural uranium "once-through" system is much simpler. The nuclear fuel is cheaper to start with and after three years in the reactor the spent fuel is simply extracted from the reactor and stored under water. The total fuel which will be used by a CANDU nuclear station in its lifetime could be stored on the site. Thus it is not absolutely necessary that reprocessing facilities be available in Canada provided reactors continue to use natural uranium as fuel. Given the present technology and state of knowledge, the Canadian natural uranium system has substantial advantages from the standpoint of waste management.

11:59 While it is not necessary to reprocess the spent fuel from CANDU reactors, it may be desirable to reclaim the substantial plutonium values (three grams in each kilogram) in the spent fuel. Plutonium will continue to be in demand and will be recycled as fuel enrichment if present research is successful. Already some quantities (over 40 tonnes) of spent fuel from Canadian reactors have been sold abroad for the recovery of the plutonium values in them. The heavy water reactor is a very efficient thermal converter for the production of plutonium.

11:60 In the United States the large and growing commitment to nuclear power means that there will be a correspondingly large nuclear fuel reprocessing industry. There will be an increasing volume of highly radioactive spent fuel moving from reactors to the fuel reprocessing plants. At present, there is only one commercial reprocessing plant in the United States but two others are in advanced stages of construction. It is estimated that four will be required to handle the fuel from the nuclear plants by 1980.

11:61 Although no satisfactory long-term solution to the storage of these very dangerous wastes has been arrived at yet, waste management is not viewed as an insurmountable problem by experts. High temperatures are created and arrangements must be made to dissipate continuously this heat for up to several hundred years. The most promising proposal to date is that the waste be buried in deep dry salt caverns, where the heat can be dissipated through the salt and other rock. Another proposal is to use special bunkers on the ground which allow better monitoring and access if necessary. However, there remains uncertainty about the long-term safe management of nuclear wastes.

THE MATTER OF HEAVY WATER

11:62 Nuclear stations similar to the Douglas Point, Pickering and Bruce family require up to one ton of heavy water for each megawatt of electrical capacity. Thus the 2,000 MW Pickering station requires close to 2,000 tons of heavy water in order to operate. Additional small quantities are required to replace the heavy water loss which occurs during the operation of the plant. The Douglas Point station encountered problems with the rate of heavy water loss but, benefiting from this experience, the Pickering station has had heavy water upkeep costs which are substantially below the planned costs.

11:63 The pressurized heavy water reactor system (Pickering for example) uses the maximum amount of heavy water but two CANDU variations use smaller amounts. Heavy water may be used only as the moderator and not as a heat

transfer medium (coolant). The Gentilly reactor in Quebec uses boiling light water while the research reactor in Manitoba uses an organic coolant. However, substantial quantities of heavy water will be required in the years to come as further power stations of the CANDU type are built.

11:64 Large heavy water production plants were originally built by the United States in the early 1950s but several years later most of this capacity was reduced or shut down. Only one plant remains in operation today and at much below capacity. This, of course, reflects the requirements of the nuclear program of the United States which does not use much heavy water. Several countries have limited heavy water inventories but production capacity outside the United States and the Soviet Union has been very limited. The Canadian heavy water plants in production or under construction make up most of the new capacity planned in the world. The story of the ill-starred heavy water plant at Glace Bay is well known and need not be repeated here.

11:65 There are several methods of producing heavy water, the technology is well known, and in fact, the main emphasis has been on reducing the cost of production. The 2,000 tons required to start up the four 500-megawatt units at Pickering, for example, is valued at $120 million – or 16 per cent of the capital cost of the plant. Accordingly, reducing the cost per ton of heavy water can have an appreciable effect on the capital cost of nuclear power plants.

11:66 The Canadian General Electric heavy water plant at Port Hawkesbury, Nova Scotia, is designed to produce about 400 metric tons per year. Up to mid-1972, the production rate has been about 18 tons per month (60 per cent of designed capacity) with nearly full production expected shortly. The Glace Bay plant, with a designed capacity of 400 tons per year, was originally scheduled to be in production in 1966. Because this proposed production did not materialize, heavy water has not been available in the quantities required for the Canadian nuclear program. The plant is now being rebuilt and the initial production is not expected before 1975.

11:67 A third heavy water plant is now under construction at Douglas Point with a planned capacity of 800 tons per year. The first 400-ton unit is expected to produce its first heavy water early in 1973.

11:68 Thus, when all three plants achieve maturity in the late 1970s, total production in Canada is expected to be about 1,500 tons of heavy water per year.

11:69 An important question concerns the future nuclear construction program of Ontario Hydro and whether or not heavy water production will be able to meet the requirements in light of the current critical shortage of heavy water. The production forecast for 1973 is about 500 tons. If this forecast is met, the quantities necessary for the Bruce generating station should be available when they are required, but indications are that production will continue to be short of demand beyond this decade.

11:70 Canada expects to sell Canadian nuclear reactors to other countries, but this seems unlikely until heavy water can be assured for these export orders. There will be long-run advantages to Ontario and Ontario Hydro when the

Canadian nuclear system becomes established in other countries, and accordingly, it is in Ontario's interest to promote steps necessary to ensure adequate production capacity of heavy water.

Table 11:7

Planned Canadian Production of Heavy Water (D_20)

Year	*Production* (metric tons)	*Comments*
1973	500	Port Hawkesbury at maximum; Bruce beginning.
1974	600	
1975	800	Glace Bay beginning.
1976	1,200	
1977	1,400	Bruce at Maximum.
1978	1,500	
1979	1,500	Glace Bay at maximum.
1980	1,500	
Total	9,000	

Source: L. R. Haywood, *Heavy Water Paper* presented at the Annual Conference, Canadian Nuclear Association, June, 1972.

11:71 A recent agreement between Atomic Energy of Canada and Polymer Corporation to collaborate in the development of advanced processes for the production of heavy water is of particular interest. The potential advantages of the new process envisaged are lower capital cost, lower energy consumption, smaller equipment, less corrosion and elimination of hydrogen sulphide from the system. It is estimated that it will be ten years before a commercial plant could be designed, built and brought into operation.

11:72 It has been suggested that package units with a production of about 50 metric tons per year should be considered. The original unit capital cost is somewhat higher but there are planning advantages which may more than offset the higher original cost.

FUTURE NUCLEAR POWER STATIONS — THE FAST BREEDER REACTOR

11:73 In the United States the reactor development program, sparked by the President's Energy Message to Congress in June, 1971, is based upon the successful introduction of the fast breeder reactor. In his message, the President noted that the fast breeder nuclear reactor offered the best hope for obtaining the United States objectives of a new energy source.

11:74 It is expected that to demonstrate a large commercial breeder by the end of this decade, the development cost will range between two and three billion dollars in addition to large industrial commitments. Basically, a breeder

reactor is able to produce more fissionable material than it consumes. Present day thermal converter reactors such as CANDU, the BWR and the PWR, utilize only one to three per cent of the uranium without plutonium recycle. The breeder will be able to use 50 to 70 per cent of the atoms in uranium, for power production. With a rapidly growing nuclear capacity and a correspondingly high usage of uranium, the date when breeder reactors will be in widespread use and will, in fact, be producing additional quantities of fuel, becomes very important. Successful introduction and widespread adoption of breeder reactors will ultimately reduce the requirement for uranium.

11:75 Research has been continuing on fast breeder reactors for many years and while various coolants have been tried, liquid metal has received the greatest attention.

Table 11:8

Liquid Metal Fast Breeder Reactors

Country	*Reactor*	*Megawatts*	*Year of Initial Operation*
United States	EBR-1	1.2 (thermal)	1951
	EBR-2	15 (electric)	1963
	FERMI	67 (electric)	1963
	SEFOR	20 (thermal)	1969
	FFTF	400 (thermal)	1974
U.S.S.R.	BR-5	5 (thermal)	1960
	BR-60	60 (thermal)	1970
	BN-350	1000 (thermal)[4]	1973
	BN-600	600 (electric)	1975
United Kingdom	DOUNREAY	15 (electric)	1959
	PFR	250 (electric)	1973
France	RAPSODIE	40 (thermal)	1967
	PHENIX	250 (electric)	1973

[4]Dual purpose: 150 MWe for power and 200 MWe equivalent for desalination.

Source: *The Nuclear Industry 1971* (WASH 1174-71), United States Atomic Energy Commission.

11:76 Commercial breeder reactors may be available in the 1990s. However, several years of operation will elapse before the reactor produces a net gain in fuel. While the time required for fuel doubling is somewhat uncertain, it is expected to be six or seven years. In any country, therefore, it will be years beyond the first fuel doubling time of the first breeder reactors before sufficient fuel is produced to meet requirements of all the nuclear plants in the system.

11:77 While the breeder reactor will have lower fuel costs than present day light water reactors, it is probable that the capital costs will be greater. Therefore, it does not follow that fast breeder nuclear plants will give lower power costs. One notable benefit is a substantially higher operating efficiency than fossil fuel plants. The waste heat from the nuclear station (i.e., the thermal pollution), will be substantially less than that produced by today's nuclear stations.

Table 11:9

Comparative Net Station Efficiencies

Fossil fuel	38-40%
BWR-PWR-CANDU	29-30%
CANDU (organic coolant)	35%
Fast Breeder	39%

11:78 Canada has no plans at present to carry out research and development programs with breeder reactors. However, CANDU reactors fuelled with thorium and primed with fissile material from an external source would come very close to producing more fissile material than they would consume. Such reactors would be virtually indistinguishable from present CANDU reactors since the thorium-232, uranium-233 cycle operates in the thermal-reactor spectrum. The fast reactor cycle, in contrast, requires the development of a complete new system. An additional benefit of the CANDU near-breeder is an increase in the electrical output per unit of uranium. There is a very good prospect therefore that the Canadian reactor system will be suitable for Canadian requirements for several decades.

FUSION POWER

11:79 In the long run, it is probable that hydrogen will become the main source of energy in the world through the creation of economic fusion power. This is the basic process by which stars produce their energy. Considerable research is under way but to date a controlled fusion reaction has not been achieved. It is interesting to note that one of the most likely routes of fusion reaction involves the deuterium isotope. Heavy water therefore may be required in quantity. Fusion power based on deuterium could provide cheap power for a very long time because it is a component of water. Further, there is the possibility of direct conversion (eliminating the thermal cycle) with efficiences of 80 per cent. However, it is not expected that fusion will be available as an economic source of power for several decades.

IMPLICATIONS FOR THE FUTURE

11:80 With all countries forecasting a continued growth in the demand for electric power, there is a growing reliance on nuclear energy as the source of electric power generation. It is expected that nuclear stations will make up 50 per cent or more of the total generating capacity in most electrical systems by the end of this century. Ontario, with no indigenous fossil fuel resources, will almost certainly fall into this group.

11:81 After more than two decades of research and experimentation in several countries, only a handful of reactor types have survived for commercial use. The Canadian-designed nuclear power system has international recognition as being one of these. However, the world market will probably be dominated by the United States light water reactors using enriched uranium. It is probable therefore, that the Canadian reactors system may have only a limited export market during the 1970s.

11:82 The number of CANDU nuclear stations installed abroad should not affect the acceptance in Canada of the CANDU system, and particularly in Ontario. After a comprehensive study and review of the nuclear programs and experience in several countries, it is our conclusion that the CANDU system has several advantages for Ontario application. In addition, the system has potential for substantial further development which could make it competitive for several decades.

11:83 Several countries are carrying out research on fast breeder reactors and great emphasis is being placed by the United States on their development. It is possible that the fast breeder could be in widespread use beginning in the 1990s, provided its present substantial economic disadvantage can be overcome. Two advantages are an expected 40 per cent efficiency, compared with the 30 per cent efficiency today, thereby reducing thermal pollution; and a capacity to produce more fissionable isotopes than are consumed. Ultimately, the demand for fresh uranium fuel may level off as recycled plutonium becomes a major source of nuclear fuel.

11:84 The Canadian heavy water reactors produce substantial quantities of plutonium and when adapted to work on the thorium cycle have "near breeder" characteristics. In addition, the uranium fuel required is approximately half that for light water reactors. These two factors reduce the urgency for introducing the fast breeder into the Ontario electrical system.

11:85 In the last analysis it is the cost of a unit of electriicty that is important. While the fast breeder will reduce the demand for uranium, it probably will not reduce the cost of a unit of electricity. The CANDU reactor, on the other hand, is capable of further development. It should continue to improve its competitive position in Ontario well into the future.

Chapter 12

Federal-Provincial Energy Relationships

JURISDICTIONAL AUTHORITY AND POLICY

Federal Government

12:1 The importance of federal involvement in the energy sector arises from federal jurisdictional authority in the field of interprovincial and external trade. The federal position is strengthened by its mineral rights in the Territories and other federal lands plus its exclusive jurisdiction over certain prescribed substances such as uranium. It exercises control over access to markets by the domestic producer or foreign supplier and access to supply by the domestic consumer and foreign customer by virtue of its regulatory authority over bulk transportation of energy sources in international and interprovincial trade by means of oil and gas pipelines and power transmission lines. The federal authorities will have direct control over major sources of hydrocarbon supplies as the frontier areas of Canada are developed.

Producing Provinces

12:2 The laws and regulations now in effect and applicable to the disposition of mineral rights, conservation measures, mineral taxation and royalties, operating and safety rules and other direct controls over mineral resources and water rights and rentals are those of the province in which the resources lie, or of

the Government of Canada if the resources lie in the Yukon or the Northwest Territories. The federal government claims the mineral rights under Canada's continental shelves although there are some provincial contentions to the contrary.

12:3 In 1970, 63 per cent of Ontario's oil supplies from western Canada delivered to Ontario refineries by pipeline were from Alberta; natural gas from Alberta represented over 94 per cent of Ontario's natural gas supply. Alberta is the dominant producing province in Canada as far as oil and gas production are concerned. It is also the major coal producer but so far it cannot economically compete with imported United States coal in the Ontario market. Nevertheless, over 35 per cent of Ontario's primary energy needs are supplied by Alberta alone.

12:4 It is the policy of the Government of Alberta to seek optimum provincial economic gains to the extent compatible with sound long-term management of the province's energy resources and associated environmental impact. The relative importance of energy resources as the mainstay of the provincial economy is made apparent by the sweeping authority and heavy responsibility vested in the Energy Resources Conservation Board on matters dealing virtually with every facet of the activities of the oil and gas, hydro and electric, and the coal industries. The responsibilities of the Board are to:

(a) Provide for the appraisal of the reserves and productive capacity of energy resources and energy for the province;

(b) Appraise market requirements for Alberta energy resources both *within* and *outside* the province;

(c) Effect the conservation of, and prevent the waste of, the energy resources of Alberta;

(d) Control pollution and ensure environmental conservation in the exploration for, processing, development and transportation of energy resources and energy;

(e) Secure safe and efficient practices in exploration, processing, development and transportation of the energy resources of the province;

(f) Provide for the recording and dissemination of information regarding provincial energy resources; and

(g) Provide agencies from which the Lieutenant Governor in Council may receive information, advice and recommendations regarding energy resources and energy.

12:5 The Board issues regulations and orders pertaining to the oil and gas industry, the hydro and electric industry, and in other matters which come within its jurisdiction; has its staff conduct inspections and make studies, conducts investigations, holds hearings and prepares reports on any matter pertaining to any act administered by it; and collects, summarizes, evaluates and publishes data.

12:6 Ontario qualifies as an energy producing province insofar as it is the major uranium producer in Canada. However, uranium as a prescribed substance, has fallen under federal jurisdiction. Ontario has not thus far exercised active authority over the management and conservation of uranium as a provincial

energy resource critical to the long-term energy needs of the province. There has not been close contact between the federal government and the Ontario government with respect to the uranium policy partly because Ontario has not been adequately oriented to its long-term dual role as both the major producer and consumer of uranium in Canada.

Consuming Provinces

12:7 While the federal government has a key role in the control of energy supplies moving from producing provinces to consuming provinces and in international trade, all provinces have the principal role in the consumer energy market, i.e. distribution and utilization. Gas and electric utilities are generally subject to provincial regulation with respect to approval of franchise, construction, right-of-way, rates and conditions of sale and service. Safety regulations are developed and administered at the provincial level, and sometimes at the municipal level as well. Nuclear safety is admistered largely at the federal level. Industry operations and technical personnel involved in distribution, equipment installation and specifications and utilization are licensed, certified or approved by provincial agencies. Except in British Columbia and Saskatchewan, all major gas utilities are investor-owned. In most of the provinces, the generation and main transmission of electric power is the responsibility of a provincial Crown corporation.

12:8 The federal government so far has not regulated the price of western crude oil delivered to Ontario refineries, but it influences petroleum product price levels in Ontario through the National Oil Policy which controls the inflow of foreign crude oil and products into Ontario. The extensive regulatory authority of the federal government over interprovincial and international transfers of energy places Ontario in a position highly sensitive to federal decision-making on energy matters. Also, energy resource development and production will be increasingly under the direct control of the federal government as the emphasis on future fuel supplies shifts to the frontier areas.

NATIONAL ENERGY POLICIES

Natural Gas

12:9 Interprovincial and international gas transmission companies are subject to federal regulatory control and must apply to the National Energy Board for Certificates of Public Convenience and Necessity before proceeding with construction of system facilities. The Board controls the quantity of gas transferred from the producing provinces for export and to the consuming provinces, the export price, the wholesale price to distributors in the consuming provinces and the duration of approvals. As a consequence, gas resource development and use is very sensitive to the decisions of the Board. The policy guidelines which underlie recent decisions of the National Energy Board may be summarized as follows:

(a) The quantity of gas to be exported should not exceed the surplus remaining after due allowance has been made for the reasonably foreseeable needs in Canada, having regard to the trends in gas discovery in Canada.

(b) The price for the gas to be exported should be just and reasonable in relation to the public interest; i.e.
   (i) the export price must recover its appropriate share of costs incurred,
   (ii) the export price should, under normal circumstances, not be less than the price to Canadians for similar deliveries in the same area, and
   (iii) the export price of gas should not result in prices in the United States market area materially less than the least cost alternative for energy from United States sources.

(c) Where a choice has to be made between licensing exports by a project wholly oriented to export and a project which serves Canadian and export customers, if all other factors are equal, the choice must be in favour of the project serving Canadian as well as export customers, thus making available to Canadian customers a share in the economies of scale and such benefits as may arise from the contribution of export to the financial health of the transmission system.

(d) When the export price is just and reasonable at the time of application but there is uncertainty as to it remaining so, the National Energy Board must review such prices during the life of such licences and where, in the opinion of the Board, there has been significant increase in prices for competing gas supplies or for alternative energy sources in the export market area, the Governor in Council may, on the recommendation of the Board, order the establishment of a new price.

(e) When the trend towards accelerated rates of take will shorten the life of the remaining reserves and reduce the protection available to meet Canadian requirements, consideration should be given to reducing the life of export licences issued.

(f) The main transmission facilities for the supply of western Canadian gas to eastern Canada must be in Canada.

These guidelines are presently being re-assessed as part of a national energy review.

Petroleum

12:10 The National Oil Policy, first introduced in 1961, is administered by the National Energy Board. Its initial objective was to attain a viable level of domestic production by increasing the domestic market for domestic crude oil and by expanding export sales to the United States. Production which had averaged only 550,000 barrels a day in 1960, averaged nearly 1,500,000 barrels daily in 1970.

12:11 The National Oil Policy was designed to stimulate western Canadian oil production and to promote Canadian development by maximizing the domestic use of Canadian oil while allowing imports to serve that part of eastern Ontario identified with the Ottawa Valley and the remainder of eastern Canada. Prior to 1961, Ontario's domestic crude oil supply was augmented by decreasing, but still appreciable, quantities of lower cost imported crude oil. Canadian oil exports[1] are virtually all to the United States and have been the subject of periodic consultation between the two countries.

[1] Export controls were introduced on March 1, 1973.

12:12 The National Energy Board has regulatory control over oil pipelines extending beyond the limits of a province. The oil pipeline company is a common carrier of its customers' oil. The applicable transmission tariff schedule is filed with the Board but so far no rate hearing proceedings have been found to be necessary. Exploration activities in Canada's Arctic include direct federal participation through Panarctic Oils Limited, an oil industry-government joint venture. As in the case of natural gas, Canada's national oil policy is presently under review.

Coal

12:13 The Dominion Coal Board was established in 1947 to advise on all matters relating to the production, importation, distribution and use of coal in Canada. The Board was also charged with the responsibility of administering any coal subventions or subsidies. In 1969-70 the Board was dissolved and the Coal Production Assistance Act and The Canadian Coal Equality Act were repealed. The functions and responsibilities of the Board were assumed thereafter by the Department of Energy, Mines and Resources.

12:14 The basic federal program of subvention aid was discontinued for the Maritime provinces in 1968 and for the Western provinces in 1971, as was loan assistance. However, alternate assistance is being provided in Nova Scotia through the Cape Breton Development Corporation and in New Brunswick through a five-year program to phase out coal production.

12:15 The new federal coal policy, nevertheless, is to promote economic viability in the coal industry through research and development and cooperative efforts with industry in the areas of mine technology and marketing, with particular emphasis on economic bulk transport from mine to markets and sulphur removal at the minehead.

Electric Power

12:16 The National Power Policy, announced in 1963, encourages the development of large-scale power sources at lowest possible cost, the distribution of benefits thereof as widely as possible through interconnections between power systems within Canada; and the export of large blocks of power where such exports will induce early development of Canadian hydraulic resources. The purpose is to take advantage wherever possible of pooling arrangements to allow rapid development of a particular renewable resource (hydro) and thereby eliminate, as far as possible, the extra costs entailed in the staged development of large projects. The normal pattern of sales agreements between members of power pools does not involve the long-term commitment of large blocks of power but rather recognizes that the surplus from a particular station which initially provides for an export to other pool members will, in due course, be absorbed within the parent region as local demand grows.

12:17 This policy permits the export of various classes of power under suitable interconnection agreements to provide for mutual assistance in emergencies and for other economic benefits which can be derived by both parties through coordinated operation and development; i.e. sales of surplus interruptible energy, diversity

interchanges, maintenance coordination, and provision of emergency standby service. Also in pursuance of these aims, the Department of Energy, Mines and Resources cooperates with other agencies in the consideration of interprovincial and international interconnections of electric power systems.

12:18 No export licence can be issued by the National Energy Board for a period in excess of 25 years and in practice licences are seldom issued for periods of longer than ten years.

12:19 Resource development has been encouraged through technology. The federal government sponsored and coordinated the design and construction of the high voltage direct current transmission system from Nelson River to southern Manitoba and has provided for ownership of the line to be passed on to that province. The federal government provided a $17.5 million loan for the construction of the Hydro-Quebec Institute of Research plus an annual grant of about $300,000; its research activities have national significance, especially the high voltage work. Also, of course, the major area of federal development has been in nuclear power which has already been covered in a previous chapter.

Uranium

12:20 Subject to Cabinet approval, all export sales of uranium must be approved by the Atomic Energy Control Board (AECB), consistent with the federal government's policy on peaceful uses announced in 1965. In 1969, the federal government set out its uranium policy in greater detail to take account of the Canadian public interest, with emphasis on resource development as well as safeguards, in light of increasing world requirements for uranium fuels and associated nuclear developments since 1965.

12:21 The federal government requires that all contracts covering the export of uranium or thorium be examined and approved by the appropriate federal agency before any application for an export permit is considered. The examination covers all aspects and implications of the contract such as nuclear safeguards, the relationship between contracting parties, reserves, rate of exploitation, domestic requirements, domestic processing facilities, and selling and pricing policy. Approval is not normally given to contracts of more than ten years' duration unless provision is made for renegotiation of price.

12:22 Once an export contract is approved, export permits covering the actual shipment of uranium or thorium may be issued annually provided that the conditions of the contract have been maintained. Approval is granted only for the supply of uranium and thorium for peaceful purposes to customers in countries with which Canada has completed a safeguards agreement, or following the coming into effect of The Non-Proliferation Treaty, with customers in countries which have concluded the necessary safeguards agreements with the International Atomic Energy Agency.

12:23 Canada permits stockpiling of Canadian uranium in foreign countries to meet the succeeding five-year requirements of each country to fuel existing or committed nuclear reactors. Additional stockpiling in Canada is not precluded,

but actual export shipment is limited to a moving five-year requirement of the foreign country. The shipment of small quantities of materials for atomic energy research projects continues to be permitted without safeguards arrangements.

12:24 Canada continues to require that all persons engaged in uranium or thorium mining in Canada be incorporated under federal or provincial legislation, that they operate under licence from the Atomic Energy Control Board and that they provide information as required under the regulations of the Board.

12:25 In the implementation and administration of these national policies, there is a need to maintain close contact with provincial governments on matters of common concern with respect to the uranium industry.

12:26 On March 2, 1970, the Canadian Government intervened to prevent the sale of Denison Mines to foreign interests so that the single largest reserve in Canada would not fall under foreign control. Currently legislative proposals to limit foreign ownership and control in the uranium and thorium sector of the economy are being reviewed by the federal government.

12:27 Although in the field of uranium exploration and mining, companies operate under provincial regulations common to the rest of the mineral industry, federal permits issued by the Atomic Energy Control Board are also required. Companies are required to submit periodic reports on their operations to the Board. The Department of Energy, Mines and Resources regards the reports as important inputs to its studies relating to the uranium industry.

12:28 The National Uranium Policy also provides for a uranium stockpile program in order to maintain minimum operations of the existing uranium producing industry until the current depressed market improves. This program was administered by the Department of Energy, Mines and Resources in conjunction with Eldorado Nuclear Limited until 1971, when a special program of stockpiling in conjunction with Denison Mines Limited alone, was instituted. Uranium Canada Limited was created to act in joint venture with Denison in the acquisition and sale of this special new stockpile. It was also assigned responsibility for the previous stockpile. This company also acts as agent of the federal government for future sales from the general government stockpile. Eldorado, a federal Crown company, operates a uranium mine on Lake Athabasca in northern Saskatchewan and the only uranium refinery in Canada located at Port Hope, Ontario.

12:29 The foregoing descriptions indicate that there is not a single overall national energy policy — rather there are a number of particular national policies relating to specific energy resources.

Chapter 13

Current Development and Coordination of Energy Policy in Ontario

13:1 The administrative machinery and legislative provisions for dealing with energy matters in Ontario are numerous and widely dispersed. At present there are some 38 major acts involving 9 ministries, as indicated in Table 13:1. There is no machinery for overall coordination and integration of energy regulation in general or public utility regulation in particular. The following is a brief review of the ministerial and administrative structure, as well as the legislation relating to energy in Ontario.

MINISTRY OF THE ENVIRONMENT

13:2 The Ministry of the Environment is responsible for The Environmental Protection Act, 1971, The Ontario Water Resources Act, The Pollution Abatement Incentive Act, The Power Commission Act, The Power Commission Insurance Act, The Power Control Act, The Rural Hydro-Electric Distribution Act and The Rural Power District Loans Act.

13:3 The first three acts empower the Ministry of the Environment with the authority and responsibility to regulate all sources of air, water and land pollution, including the quality of fuels used in combustion so as to limit undesirable stack emissions, the control of condensate heat emissions to lake waters by thermal power plants, and the prevention of physical, chemical and radiological pollution from all active and inactive uranium mining and refining operations.

13:4 The remaining acts for which the Ministry is responsible provide The Hydro-Electric Power Commission of Ontario with wide powers in relation to the generation, transmission and distribution of power throughout the province. The Commission has regulatory and quasi-judicial authority over other producers of electricity, local utilities and the design, installation and use of electrical wiring equipment and devices.

13:5 The Ministry of the Environment administers the payments to Ontario Hydro for the province's portion of the cost of construction of units 1 and 2 of the Pickering Nuclear Generating Station. Now that these units are commissioned, the Ministry is the recipient of monthly paybacks to the extent that this station has operational savings in comparison with Ontario Hydro's coal-fired station at Lambton as stipulated in the agreement between Ontario Hydro, Atomic Energy of Canada Limited and the Province of Ontario. The Ministry also provides funding assistance for northern electrification.

MINISTRY OF NATURAL RESOURCES

13:6 The Ministry of Natural Resources is responsible for the administration of The Gas and Oil Leases Act, The Mining Act, The Mining Tax Act, The Ontario Energy Board Act, The Petroleum Resources Act, 1971 and The Water Powers Regulation Act.

13:7 Under The Mining Act, the Ministry is responsible for issuing boring permits for the exploration for oil, gas and coal in those parts of Ontario lying north and west of the Mattawa River, Lake Nipissing and the French River and also Crown lands lying south and east of this land. In general, this act charges the Ministry with responsibility for the disposition of mineral rights on Crown lands, the collection of certain fees and mining taxes, the control of mining operations, the establishment of mineral refineries and all regulations made with respect to mines or minerals or mining or mining lands or mining rights. The Ministry is also concerned with mapping the geology of the province and in providing prospectors and the mining industry with geographical maps and reports as an aid in the search for and development of mineral resources.

13:8 The Mining Tax Act provides for the taxation of oil and gas recovering operations, mining taxation in general, and uranium in particular.

13:9 Under the authority of The Petroleum Resources Act, 1971, the Ministry is responsible for the licensing, regulation and inspection of exploration, drilling and production operations and facilities, and the collection and dissemination of engineering and geological data and information on oil and gas resources in the province.

13:10 The Water Powers Regulation Act provides for the regulation of terms and conditions upon which water powers or privileges granted by the Crown may be sold or leased and developed.

13:11 The Ontario Energy Board operates under the authority of The Ontario Energy Board Act and under certain sections of The Petroleum Resources Act, The Municipal Franchises Act, The Public Utilities Act and The Assessment Act.

Essentially, The Ontario Energy Board Act designates and empowers the Board with the regulation of rates, charges and construction regarding the transmission, distribution and storage of natural gas and with respect to matters of public convenience and necessity. In addition to its gas utility regulatory role, the Board grants leave to construct pipelines and authorizes expropriations for such construction, regulates the underground storage of natural gas, adjudicates disputes concerning pooling and unitization, and is responsible for the proration of production of oil and gas. The Board investigates other energy matters referred to it by the Lieutenant Governor in Council or by the Minister.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

13:12 The Ministry of Transportation and Communications administers The Public Service Works on Highways Act whereby there is provision for the division of expenses in the relocation of utility lines (electrical and steam power, gas pipelines, etc.) because of highway construction or alterations. Where there is a claim for compensation by the road authority and no agreement can be reached with the utility, the compensation is determined by the Ontario Municipal Board.

13:13 Also, this Ministry is responsible for the development of policy in certain areas which can have direct implications for the energy sector. For instance, specific mass-transit policy could influence private-vehicle usage and the demand for vehicle fuel. A shift to electrification could increase electrical demand.

MINISTRY OF THE ATTORNEY GENERAL

13:14 The Ministry of the Attorney General's statutory responsibility includes The Expropriations Act, The Ontario Municipal Board Act, and The Ministry of the Attorney General Act.

13:15 The Expropriations Act establishes the powers to be exercised, the procedures to be followed and the requirements to be met by the authorized expropriating authorities. For example, the Ontario Energy Board is both the expropriating authority and the approving authority in the case of pipeline rights-of-way. Under The Power Commission Act, Ontario Hydro is the expropriating authority and the Minister of the Environment is the approving authority.

13:16 Under the provisions of The Ontario Municipal Board Act, the Board has broad powers which include the regulations of accounts and rates of all public utilities that are operated by or under the control of a municipality or local board except for the operations of public electric utilities obtaining power from Ontario Hydro and except for the operations of privately owned gas utilities.

13:17 Pursuant to The Ministry of The Attorney General Act, the Crown Law Office of that Ministry has supplied counsel and advisory services to the Ontario Energy Board. In addition, counsel from the Crown Law Office represents the Province of Ontario when interventions are made before the National Energy Board following the service upon the Attorney General of applications pending before that Board. The Crown Law Office also advises the Petroleum Resources Section of the Ministry of Natural Resources.

MINISTRY OF CONSUMER AND COMMERCIAL RELATIONS

13:18 The Ministry of Consumer and Commercial Relations is responsible for, among other things, The Boilers and Pressure Vessels Act, The Condominium Act, The Energy Act, 1971, The Gasoline Handling Act and The Operating Engineers Act.

13:19 The Boilers and Pressure Vessels Act concerns the safety of design and operation of boilers and pressure vessels where the source of heat is a flame or rays from a radioactive source, or molecular agitation arising from the process of nuclear fission.

13:20 The Energy Act, 1971, provides for the regulation of handling and use of hydrocarbons used as a fuel, either liquid or gaseous. More specifically, it is intended to provide for the safety of persons and property in the transmission, transportation or distribution of a hydrocarbon, or the storage of a hydrocarbon in a container.

13:21 The Gasoline Handling Act concerns the storage, transmission, transportation or distribution of gasoline, and controls the dispensing of gasoline into the fuel tank of a motor vehicle or water craft or into a container.

13:22 The Operating Engineers Act involves the certification of qualified persons for the actual operation of a stationary plant, or hoisting plant or a temporary heating plant. The initial source of motive power includes an electric motor, an internal combustion engine, a steam engine, and a steam or gas turbine.

MINISTRY OF THE SOLICITOR GENERAL

13:23 The Ministry of the Solicitor General is responsible for The Emergency Measures Act and The Fire Marshal's Act.

13:24 The Emergency Measures Act assigns to the Premier or his designated minister the power to direct and control electrical and gas supply, distribution and use in each municipality in an emergency area.

13:25 Under The Fire Marshal's Act, the Fire Marshal's office is responsible for investigating accidents involving fire or explosion. Under The Energy Act, 1971, the Energy Branch of the Ministry of Consumer and Commercial Relations has the same responsibility, only limited to those occurrences involving hydrocarbons.

MINISTRY OF REVENUE

13:26 The Ministry of Revenue is responsible for The Assessment Act (except for the Assessment Review Court), The Gasoline Tax Act, and The Motor Vehicle Fuel Tax Act.

13:27 One section of The Assessment Act specifies that all disputes as to whether or not a gas pipeline is a transmission line, on application by any interested party, shall be decided by the Ontario Energy Board and its decision is final.

13:28 The other two acts assign the responsibility for administering the taxation of fuel used to propel motor vehicles to the Ministry of Revenue and specifies the tax rates and applicability.

MINISTRY OF TREASURY, ECONOMICS AND INTERGOVERNMENTAL AFFAIRS

13:29 The Ministry of Treasury, Economics and Intergovernmental Affairs statutorial responsibilities include The Municipal Affairs Act, The Municipal Act, The Municipal Franchise Extension Act, The Municipal Franchises Act, The Planning Act, The Public Utilities Act, The Public Utilities Corporations Act and The Statistics Act.

13:30 Under The Municipal Affairs Act, the Ministry administers all acts in respect of municipal institutions and municipal affairs. The Ministry has control over the exercise by any municipality and local board of their powers concerning rates, rents and charges imposed for supply or service of any public utility, subject to The Power Commission Act.

13:31 The Municipal Act is broad in scope and embraces the entire spectrum of municipal affairs, detailing the powers, organization and procedures of municipal governments including the passing of by-laws for construction, use and maintenance of utility facilities in or upon municipal land, the financing of public utilities, the regulation of public garages and service stations, the regulation of heating and cooking appliances, installation of appliances and storage of fuel, and the overall regulation of underground utility facilities.

13:32 The Municipal Franchise Extension Act and The Municipal Franchise Act specify the conditions and procedure by which a municipality may grant a franchise for the construction or operation of a privately owned utility. In the case of a gas utility, the terms and conditions of a specific franchise must be approved by the Ontario Energy Board before the franchise-granting by-law can be submitted to the municipal electors for their assent.

13:33 The scope and general purpose of The Planning Act involves, among other things, certain implications for the energy utilities with respect to drainage, land use, communications and public works.

13:34 The Public Utilities Act facilitates the formation and operation of municipal works for the production, procurement and supply of public utilities.

13:35 The Ministry also administers water power rental agreements with Ontario, Hydro-Quebec and The Power Authority of New York State.

ONTARIO ENERGY BOARD

13:36 The Board acts under the authority of The Ontario Energy Board Act, and under certain sections of The Petroleum Resources Act, The Municipal Franchises Act, The Public Utilities Act and The Assessment Act.

13:37 The terms and conditions of franchise agreements between a municipality and a gas utility must be approved by the Board before the gas utility can distribute gas in the municipality. The gas utility (distributor) requires a Certificate of Public Convenience and Necessity, and authority to expropriate land that may be required for pipelines and stations. Before gas can be retailed, rates must be fixed and approved by the Board. Also, any proposals of gas companies to sell their systems, merge or acquire shares of another gas company, are subject to review by the Board. All of these proceedings involve conflicting interests which are considered in public in open hearings. The Board acts as a court in requiring attendance and examination of witnesses, presentation of necessary documents, and enforcement of its orders. In the final analysis, the Board prepares, in writing, its reasons for decision and its order to the applicant. Board decisions are usually final but it may reopen a hearing, or review its decisions, and vary or rescind its previous order. The Lieutenant Governor in Council has power to set aside an order of the Board.

13:38 In addition to gas utility regulation, the Board has similar authority over oil and natural gas transmission lines (bulk transport) and over the storage of natural gas in natural underground formations.

13:39 The Board also fills an advisory role on matters referred to it by the Lieutenant Governor in Council or the Minister. And finally, the Board administers a uniform system of accounts to which the regulated gas companies must comply.

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

13:40 Under the terms of provincial legislation, Ontario Hydro is granted wide powers of authority in relation to the generation, transmission and distribution of power throughout the province. Further, it receives regulatory and quasi-judicial authority over other energy producers and local electrical utilities. This authority is found in The Power Commission Act and The Power Control Act, which also specify the limited restraints placed upon Ontario Hydro in relation to the provincial government, e.g., appointments to the Commission, etc.

13:41 Control is exercised at the federal level under the terms of The National Energy Board Act, which brings Ontario Hydro under the control of the National Energy Board in the event of the import or export of power to or from Canada. Furthermore, all nuclear plants and nuclear training facilities are subject to regulation by the Atomic Energy Control Board.

13:42 Under the terms of The Power Commission Act, Ontario Hydro has a regulatory function in two areas: first, in the area of electrical safety which covers any electrical equipment, electrical installation and wiring throughout the province; secondly, in the regulation of the affairs of the local municipal electrical utilities.

13:43 Under the authority of The Power Commission Act and The Public Utilities Act, Ontario Hydro regulates primarily those utilities with which it has

contracted to supply power. The regulated utility cannot raise money without first obtaining the consent of the Commission as to the amount and the purpose. All rates, charges and acquisitions and dispositions affecting property value are subject to Ontario Hydro approval. The salaries or other remuneration of the municipal utility commissioners require approval also. A prescribed system of accounting is subject to audit by Ontario Hydro.

13:44 The Power Control Act gives the Commission broad potential authority to regulate all power suppliers and distributors but so far the Commission has not exercised active regulatory control over electric utilities with which it has no supply contract.

13:45 The Commission acts as an appeal board to whom application may be made for some alteration or review of municipal rates. There is, however, no provision for appeal by those customers who receive their power directly from the Commission.

ONTARIO MUNICIPAL BOARD

13:46 The Ontario Municipal Board has broad powers over the utilities which are not subject to the Ontario Energy Board and Ontario Hydro. Its scope goes beyond gas and electric utilities, covering other utility services.

13:47 The Board comes under the Ministry of the Attorney General, and receives most of its authority from the following legislation:

The Ontario Municipal Board Act

The Local Improvement Act

The Municipal Act

The Municipal Arbitrations Act

The Municipal Franchises Act

The Municipal Corporations Quieting Orders Act

The Planning Act

The Public Utilities Act

The Public Works Act

The Public Service Works on Highways Act

13:48 Despite its broad powers the Ontario Municipal Board does not in practice regulate closely those municipal utilities under its jurisdiction. Apart from matters of utility capital funding, the Board functions more as a referee in the event of utility disputes in such areas as sharing public rights-of-way and allocation of associated costs.

ONTARIO ENERGY SAFETY REGULATION

13:49 The activities of the Energy Branch, Ministry of Consumer and Commercial Relations, administering The Energy Act, 1971, and The Gasoline Handling Act are concerned primarily with the safety of people in an area that includes the expanding usage of hydrocarbon fuels in the province.

13:50 Safety standards relating to equipment and operational procedures are enforced by means of inspection, supervision and mandatory approvals. Field instruction and guidance are provided to the public, and to such others as contractors and municipal personnel who are involved in matters relating to the safe handling of natural gas, propane, fuel oil and gasoline.

13:51 The Branch is responsible for establishing acceptable operational standards and specifications relating to the transmission, distribution, storage and transportation of fuels, safe use of heating fuels, maintenance of appliances and equipment, dispensing of automotive fuels, and installation and operation of storage, distribution and dispensing facilities. In addition, the Branch has a certification function whereby gas fitters, propane fitters, pipeline inspectors and oil burner mechanics are instructed, examined and certified. As part of its safety program, the following are licensed and registered: natural gas transmitters, distributors of natural gas, propane and pipeline fuel oil; heating appliance contractors; operators of bulk storage plants; service stations, wholesale outlets; and vehicles transporting petroleum products.

13:52 Ontario Hydro develops and administers electrical safety standards for design, installation and operation. These standards are enforced by authorized laboratory testing and approval of electrical equipment and installation inspection. Regulations can also prohibit the sale of equipment which does not meet Ontario Hydro standards.

COMMENTS ON REGULATORY ARRANGEMENTS IN ONTARIO

13:53 The three major gas distributors have made representations to the Advisory Committee on Energy regarding the wide dispersion of regulatory responsibility for the industry. Responsibility for setting overall energy policy, partciularly with regard to Ontario's position on federal energy policy matters, has been assumed by the Ministry of Treasury, Economics and Intergovernmental Affairs and by the Ministry of the Attorney General. There are several pieces of legislation which infringe upon the gas industry sometimes with major impact, and which come under different ministers. A unanimous recommendation by the gas industry is for a policy providing for a concentation of all authority regarding gas matters in one place which would:

(a) facilitate the development of an appropriate posture for the province in federal energy matters,

(b) ensure that such posture is consistent with internal provincial policy,

(c) permit continuing useful dialogue between industry and government, and

(d) ensure uniformity in standards and procedures in energy sector regulation.

RESEARCH AND INFORMATION

13:54 The Government of Ontario and its administrative agencies have had no major direct involvement in energy-sector research and development. Indirectly, the government is engaged in research and development through Ontario Hydro. Its most active work is concentrated on immediate development projects in power transmission, disposal of waste heat, power plant heat exchangers, thermostatic control of room temperature, solid-state electronic station control equipment, and materials testing. Ontario Hydro is not directly involved in nuclear research because of the existing capability of Atomic Energy of Canada Limited in this area. The Ontario Research Foundation has accumulated significant expertise in process development associated with resource-based industries. It has also assisted industry in the energy sector in the development of such equipment as high efficiency combustion furnaces.

13:55 The province does not have an active research and development program for energy resource development except for the traditional development of geological data, hydraulic power development by Ontario Hydro, and the present project to determine the economic feasibility of the Onakawana lignite deposits. Statistics, forecasts and special studies relevant to the energy sector are prepared regularly within the ministries on a continuing basis as an industry and public service and for keeping government personnel up to date on trends and new technology. This work is performed largely by the Energy Studies Section currently attached to the Ontario Energy Board and the Petroleum Resources Section in the Ministry of Natural Resources. On the other hand, Treasury Economics and Intergovernmental Affairs has been active in studying energy policy alternatives, including the implications of Ontario Hydro capital financing. However, there is no established method of integrating the work of these organizational units.

Table: 13:1

Legislation in The Energy Sector

M—resource management
S—safety
U—utility

F—financial
O—Crown Agency operation
X—miscellaneous

1—direct energy legislation
2—indirect energy legislation

POLICY FIELD →	Resources Development				Justice				
Ministry → / Legislation ↓	Environment	Labour	Nat. Resources	Trans. & Comm.	Attorney General	Cons. & Com. Rel.	Solicitor General	Revenue	Treas. Econ. & I. A.
Power Commission Act	M1								
Gas & Oil Leases Act			M1						
Petroleum Resources Act			M1						
Water Powers Regulation Act			M1						
Mining Act			M2						
Environmental Protection Act	M2								
Ontario Water Resources Act	M2								
Pollution Abatement Incentive Act	M2								
Power Commission Act	S1								
Energy Act						S1			
Gasoline Handling Act						S1			
Boilers & Pressure Vessels Act						S2			
Operating Engineers Act						S2			
Fire Marshal's Act							S2		
Trench Excavators' Protection Act		S2							
Power Commission Act	U1								
Power Commission Insurance Act	U1								
Power Control Act	U1								
Ontario Energy Board Act			U1						
Petroleum Resources Act			U1						
Assessment Act								U1	
Municipal Franchises Act									U1
Municipal Franchises Extension Act									U1
Public Utilities Act									U1
Municipal Affairs Act									U2
Municipal Act									U2
Planning Act									U2
Public Utilities Corporation Act									U2
Public Service Works on Highways Act				U2					
Expropriations Act					U2				
Ontario Municipal Board Act					U2				
Ministry of the Attorney General Act					U2				
Securities Act						U2			
Condominium Act						U2			
Emergency Measures Act							U2		
Rural Hydro-Electric Distribution Act	F1								
Rural Power District Loans Act	F1								
Gasoline Tax Act								F1	
Motor Vehicle Fuel Tax Act								F1	
Mining Tax Act			F1						
Pickering Nuclear Generating Station Agreement	F1								F1
Water Power Rental Agreements			F1						
Power Commission Act	O1								
Statistics Act									X2

HEAT VALUES

Petroleum (per barrel)	*Million Btu*
Crude Oil	5.80
Liquefied Petroleum Gas Average	4.00
Motor Gasoline	5.22
Turbo Fuel	5.41
Kerosene & Stove Oil	5.68
Diesel & Light Fuel Oil	5.83
Heavy Fuel Oil	6.29
Natural Gas (per mcf)	1.00
Coal (per short ton)	
Bituminous	26.2
Lignite	10.0-18.0
Fuel Wood (per cord)	20.0

Electricity

The efficiency of a large thermal station for the generation of electrical energy is given by the ratio, electrical energy output divided by the maximum energy input which can be released by burning the fuel. One kilowatt-hour (3,412 Btu) of electrical output will require:

from older coal-fired stations 11,400 Btu input for an efficiency of 30 per cent,

from Lambton generating station 8,500 Btu input for an efficiency of 39 per cent, and

from Pickering nuclear station 11,750 Btu input for an efficiency of 29 per cent.

The generally accepted overall heat input value for coal-fired stations is 10,000 Btu per kilowatt-hour of electricity produced. For purposes of aggregation and comparison, this same heat value is used as an equivalent input for hydro and nuclear electric generation.

Uranium

The conversion, or "burning", or uranium fuel by fission in a reactor to release thermal energy may be expressed either by the percentage of fissionable atoms which have undergone fission or by the thermal energy released from unit weight of fuel in which fission takes place. The fuel "burn-up" for Pickering nuclear station, for example, is 8,000 megawatt-days thermal energy per metric ton of natural uranium fuel or 297 Btu per pound of natural uranium. The design burn-up for the Bruce nuclear station is 9,600 megawatt-days per metric ton of natural uranium. Because of the wide variation in fuel "burn-up" amongst the various nuclear reactors there is no standard "heat rate" for nuclear reactor generating stations as there is for stations in which fossil fuels are burned.

APPENDIX A

MEMBERS OF THE ADVISORY COMMITTEE ON ENERGY

Chairman: **DR. J. J. DEUTSCH**
Principal and Vice Chancellor
Queen's University

Executive Director: **S. W. CLARKSON**
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C. L. MORT
The Canadian Chemical Producers' Association

H. A. REGIER
Pollution Probe at the University of Toronto

DR. J. K. REYNOLDS
Government of Ontario

R. G. SAMWORTH
Propane Gas Association of Canada

H. W. SHEA
The Petroleum Association of Ontario

J. C. THATCHER
Government of Ontario

Ex officio members of and liaison officers to the Committee:

R. M. DILLON
Task Force Hydro

G. M. MacNABB
Government of Canada

Former member of the Committee:

R. G. QUILLIAN
Ontario Petroleum Institute Inc.

APPENDIX B

STAFF OF THE COMMITTEE

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DR. E. C. SIEVWRIGHT Director of Research	E. C. Sievwright Associates Limited, Toronto
P. F. CUNNINGHAM Executive Officer	Ministry of Industry and Tourism
D. R. COCHRAN Senior Research Officer	Ontario Energy Board
W. B. GANONG Senior Research Economist	Advisory Committee on Energy
A. DRORY Research Economist	Advisory Committee on Energy
MISS B. E. JESSON Research Assistant	Advisory Committee on Energy
MISS C. A. KANE Secretary to Mr. Clarkson	Ontario Energy Board
MISS M. E. FRATER **MRS. G. J. GODDEN** **MISS G. IRVINE** Secretarial Staff	Advisory Committee on Energy

APPENDIX C

GOVERNMENT STAFF AND OTHERS ASSISTING THE COMMITTEE

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J. O. BEAULIEU, Task Force Hydro

L. BODNAR, Ministry of Treasury, Economics and Intergovernmental Affairs

I. BUTTERS, Ontario Economic Council

C. M. CHESNEY, Ministry of Revenue

H. A. CLARKE, Ministry of Environment

R. L. COHEN, The Hydro-Electric Power Commission of Ontario

W. P. CORKING, Consumers' Association of Canada (Ontario)

D. P. DEMPSTER, Ministry of Industry and Tourism

W. L. DICK, Ministry of the Environment

DR. A. R. EMERY, Ministry of Natural Resources

DR. W. FRUEHAUF, Ministry of Treasury, Economics and Intergovernmental Affairs

R. O. GIBSON, Ministry of Revenue

Q. F. HESS, Ministry of Natural Resources

L. T. HIGGINS, The Hydro-Electric Power Commission of Ontario

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B. G. KELLY, Pollution Probe at the University of Toronto

B. C. LEE, Ministry of Natural Resources

DR. M. D. PALMER, Ministry of the Environment

T. B. REYNOLDS, The Hydro-Electric Power Commission of Ontario

MRS. D. L. SANTO, Ministry of Treasury, Economics and Intergovernmental Affairs

R. A. SCOTT, Q.C., Ministry of the Attorney General

D. A. SHARP, Ministry of Natural Resources

J. B. SMITH, Task Force Hydro

E. W. STOBART, Ministry of the Environment

DR. K. E. TEMPELMEYER, Ministry of the Environment

G. M. WOOD, Ministry of the Environment

K. H. ZUBE, Ministry of Industry and Tourism

APPENDIX D

ORGANIZATIONS FROM WHICH SUBMISSIONS WERE RECEIVED

Canadian Commercial Coal Dock Operators Association

Canadian Industries Limited

The Chemical Institute of Canada

The Conservation Council of Ontario

The Consumers' Gas Company

Dow Chemical of Canada, Limited

Engineering Institute of Canada, Hamilton Branch

Farmers' Gas Company Limited

Firestone Tire & Rubber Company of Canada Limited

Gulf Oil Canada Limited

The Hydro-Electric Power Commission of Ontario

Imperialle Fuels Co. Limited

Imperial Oil Limited

Long Beach Private Property Owners Association

New Metalore Mining Company Ltd.

Northern and Central Gas Corporation Limited

Ontario Fruit and Vegetable Growers' Association

Pollution Probe at the University of Toronto

Polymer Corporation Limited

Propane Gas Association of Canada

Ram Petroleums Limited

Shell Canada Limited

Sierra Club of Ontario

Texaco Canada Limited

TransCanada PipeLines Limited

Union Gas Company of Canada, Limited

Universal Terminals Ltd.

APPENDIX E

INDIVIDUALS FROM WHOM SUBMISSIONS WERE RECEIVED

Adey, R.	Oakville
Bardawill, Victor G.	Aylmer
Burgess, John D.	Union
Goering, Jack W. L.	Port Hope
Hatley, James J.	Orillia
Hoes, P. J.	Peterborough
Johnson, Arthur C.	Ithaca, N.Y.
Taylor, John L.	Kingston
VandenHazel, B. J.	Woodstock

APPENDIX F

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[1]All documents and records of the Advisory Committee on Energy are on file in the offices of the Ontario Energy Board.

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SPECIAL CONSULTANT TO THE COMMITTEE

A. R. Crozier, former Chairman, Ontario Energy Board.

APPENDIX H

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APPENDIX I

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